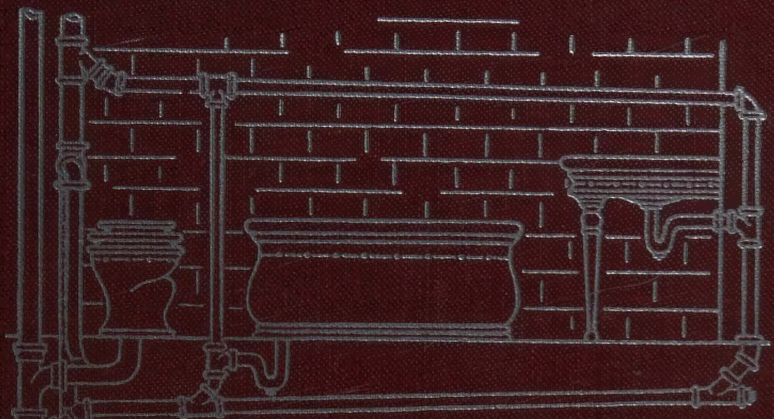
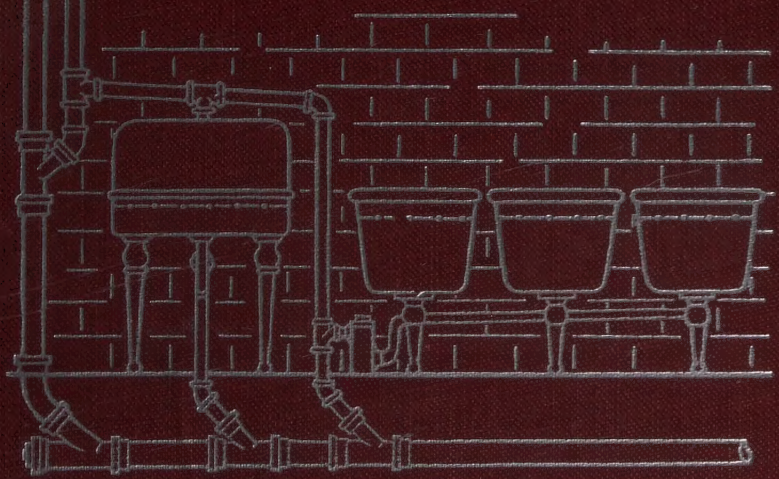


STANDARD PRACTICAL PLUMBING

R. M. STARBUCK



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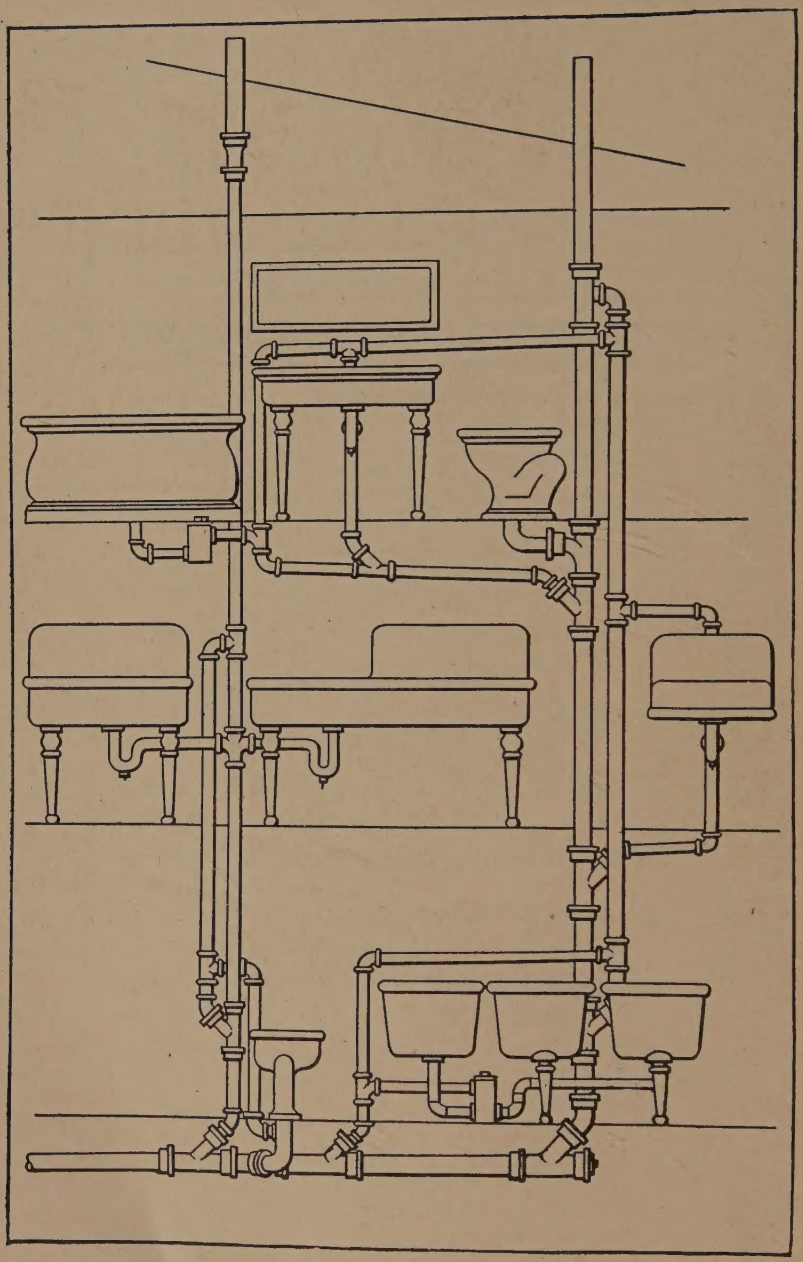

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By R. M. STARBUCK

Author of "Modern Plumbing Illustrated," "Mechanical Drawing for Plumbers," "Questions and Answers on the Theory of Sanitary Plumbing," etc.

EIGHTH REVISED AND ENLARGED EDITION

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PREFACE

In general, the writing of works such as that which the author herewith presents, is accompanied by several features the effect of which is to materially lessen the excellent results which such a work should produce.

One of the errors to which we allude, is the tendency of the author on trade subjects to write in too technical a manner, that is, to handle his subject in such a manner that none but the most educated of his readers are able to thoroughly grasp the principles presented.

For instance, since the plumber is seldom to be found who can handle an algebraic equation, it would certainly seem far better to present a necessary principle by means of arithmetic rather than by means of algebra, and if there is no other way than by means of algebra the author should see to it that he fully explains the entire operation at length, in such a manner that the reader who has not had the advantage of instruction in such branches may be able to grasp the subject. In other words, the author should stand in the same position to his readers that the teacher does to his pupils. It is his duty to honestly instruct, and not merely to fill his pages with facts which, though valuable, are presented in such a manner as not to be easily understood by the average reader.

A second serious though unintentional error on the part of many authors is the omission of minor details. While to the author, who is naturally a man of experience and education in his special line of work, the statement of simple, and to him obvious facts, seems a matter of foolishness, ofttimes, to many of his younger and more inexperienced readers, the statement of these simple things is a matter of utmost importance, and a means of establishing the main principle more strongly in their minds.

The author of this work frankly confesses to surprise at the absence of knowledge of rudiments which he knows from long experience to exist, and, knowing that this condition does exist, has no apology to offer for the statement of various facts in his writings which certainly should be known and understood. In-

deed, it is his firm belief that one of the chief factors in obtaining whatever success has come to him in his line of work, is the fact that he has never hesitated to give the minor details and to state simple facts. Certainly if these are not thoroughly understood, the main subject under consideration cannot possibly be digested as thoroughly as it should be.

A third defect that often creeps into trade text books is the lack of systematic treatment of the various subjects considered.

A book so written cannot give to the reader as clear an understanding as a work which takes up the various subjects in proper order. By this we do not mean to infer that there is only one order that may be properly followed, but merely to emphasize the fact that the mere statement of facts is not sufficient. There must be a proper order.

Knowing the tendency toward these errors the author has honestly endeavored to avoid them, and to give his readers such information as will be of practical use to them.

We need to say something concerning the new revised and enlarged edition of this work which is here presented to you.

The book has now passed through several revisions, these having been made necessary by continued improvement and progress in plumbing practice.

In the preceding revision we made many changes because of the very general introduction of continuous venting.

At the time of the present revision, possibly the most important feature to note is the attempt that is gaining ground rapidly, looking to the simplification of the plumbing system, this being done without affecting the efficiency that has been attained in the present system.

The United States government, through the Department of Commerce, and under the guidance and inspiration of Secretary Herbert Hoover, has given this program of simplification a tremendous impetus.

This has been brought about by the publication of a government report on plumbing.

This is of such importance that we have felt justified in devoting an entire new chapter to the consideration of certain of the features contained in this report.

R. M. Starbuck.

November, 1926.

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INTRODUCTION

THE intention of the author in presenting this work has been to produce something in the nature of a text book, which should not only appeal to the beginner as a book of instruction, but to his more advanced brother as a book of reference, as comprehensive as our allotted space would allow.

Starting then, with the consideration of the tools of the plumber, the author has in his earlier pages taken up briefly the subject of the manual work of the plumber, following which come several chapters on the various phases of trapping, venting and drainage. This is followed by chapters on certain important classes of plumbing construction. The latter part of the work is devoted to the general subject of hot and cold water supply, and to several special subjects, including a chapter on mechanical drawing, which is especially designed to meet the requirements of the plumber.

As generally applied to-day, the word "plumbing" includes not only the drainage and vent systems, which in reality are parts of the same system, but also the water supply, both hot and cold water piping. Originally by the word "plumber," was meant a lead worker, but the common significance of the term is now entirely different.

Many of the workmen of large firms doing plumbing construction are specialists along certain lines of their trade, but in general, the present-day plumber is required to understand and work at both branches of his trade. It therefore becomes necessary in any comprehensive treatise on the subject of plumbing, to consider both the drainage and water supply systems.

Both these systems have in the past undergone great changes,

and are at the present time undergoing change. In general these changes mark great progress, and while it is difficult to see how plumbing construction can be perfected much beyond the point which it has now reached in some sections of the country, it is entirely in the nature of things to look for still further improvement. In conjunction with such improvement, we believe that a less complicated plumbing system is to be the result, and the attainment of such a result should be looked upon with favor.

There has always seemed to be a tendency on the part of the plumbing trade to look upon time-honored practice as something that must not be disturbed, and because of this, advancement has sometimes been accomplished only against great difficulties. Nevertheless, if the new is better than the old, it is bound to be accepted sooner or later, and we should always have an open mind on these things, and be ready to take the advance step when it is clearly seen that something better is in store in our line of work than we have had in the past.

In the preface we mention the fact that we have added in this present revision a new chapter dealing with the extended investigation and experimental work that our national government has been carrying on, into various phases of plumbing practice.

In connection with what we have already said concerning the simplification of plumbing, we need to say that from the beginning of this government investigation, one of the principles underlying the work was this very thing,—a simplified system.

We are very glad to say that in our opinion great advances have been made toward such a system, and it goes without saying that anyone connected in any way with the plumbing industry, should welcome such simplification whenever it can be accomplished without lessening the high state of efficiency that the present system has reached.

It will not be out of place to say that in some of the author's other books, other features of simplified plumbing have been considered in recent revisions, and we feel it a duty to urge the study of the simplified methods, with unprejudiced mind.

STANDARD PRACTICAL PLUMBING

CHAPTER I

THE PLUMBER'S TOOLS

The tools which the plumber is now called upon to use in connection with his work are of quite different nature to those used previous to the advent of the present methods of construction.

This change is due, in the first place, to the fact that the plumber is now provided with manufactured lead traps, bends, offsets, etc., and it is no longer necessary for him to make these things himself.

Furthermore, it is a fact that the use of lead for all purposes of plumbing construction, whether on the drainage system or vent system, in the installation of fixtures, or in the lining of tanks and safes, has been, and is being, superseded by the use of other materials.

To be sure, it is principally on large work in the larger cities that lead work has been entirely given up, but the tendency is strongly that way on smaller work in all parts of the country.

It is the purpose of this chapter to explain the uses of some of the more important tools, to give some advice as to the selection of proper tools, and to show the advantages of certain tools of recent construction.

The plumber's "kit" should include the following tools: Gas pliers, pocket pliers, screwdriver, compasses, rasp, file, saw, compass saw, rule, tape, plumb bob, hammer, monkey wrench, bit brace and bits, pointed copper, hatchet copper, rosin and grease box, spirit level, $2\frac{1}{2}$-in. and $3\frac{1}{2}$-in. ladles, pothook, tap borer, bending pin, turn pins Nos. 1, 2, and 3, 1-in., $1\frac{1}{4}$-in., $1\frac{1}{2}$-in., and 2-in. drift plugs, shave hook, dresser, small mirror, wiping cloths, 1-in., $1\frac{1}{4}$-in., $1\frac{1}{2}$-in., and 2-in. sand plugs, cold chisels, calking tools, joint runner, 1-in., $1\frac{1}{4}$-in., $1\frac{1}{2}$-in., and 2-in. bending springs, lead-pipe cutter, and 10-in. and 14-in. pipe wrench. A more complete kit may contain numerous other tools, such as chipping knife,

washer cutter, candlestick, basin wrench, brass-pipe wrench, pipe holders, snips, hack saw, etc.

In most cases the employer is expected to furnish all such tools as stocks and dies, pipe cutters, plumbers' furnaces, metal pots, vises, taps, reamers and drills, large pipe wrenches, pipe tongs, torches, large ladles, large joint runners, brass-pipe vises, etc.

There are numerous special tools which are to be found in the outfits of many workmen which are not named in the above lists. In Fig. 1 are shown some of the more common and more essential plumbers' tools, a few words concerning which may be of value. The metal pot is used for holding wiping solder and calking lead, and is made in the following diameters: 5 in., 6 in., 7 in., 8 in., 9 in., 10 in., and 12 in. The smallest size is used principally for wiping solder, the 6-in. and 7-in. sizes for calking lead on the smaller sizes of pipe, and the larger sizes for lead used on larger sizes of pipe.

Ladles, used in pouring wiping solder and calking lead, are made either single- or double-lipped and in the following sizes: $2\frac{1}{2}$ in., 3 in., $3\frac{1}{2}$ in., 4 in., 5 in., 6 in., 7 in., 8 in., 9 in., and 10 in. The $2\frac{1}{2}$-in. and 3-in. sizes are mostly used on wiping solder, and the larger sizes for lead, the size depending on the size of the pipe on which joints are to be poured. The double-lipped ladle is generally considered preferable to the single-lipped, especially on lead pouring, as the metal may be poured from either side of the ladle without changing hands.

The pothook is used for lifting pots of hot metal.

The plumber uses a bending pin for throwing up an edge on lead pipe in preparing it for wiping. For instance, in wiping a pipe onto a drum trap, a hole is cut into the side of the trap of less diameter than desired, and by means of the bending pin the metal outside the hole is beaten out to form a collar into which the pipe may fit, the collar then being beaten close down to the pipe. The bending pin would be used in the same way for connecting a branch into a lead pipe. There are three styles in use, as shown in the illustration, the use of the different forms being a matter of taste of the workman. The form having one end bent and the other straight is probably mostly used.

The tap borer is used in boring a hole of any size into the side

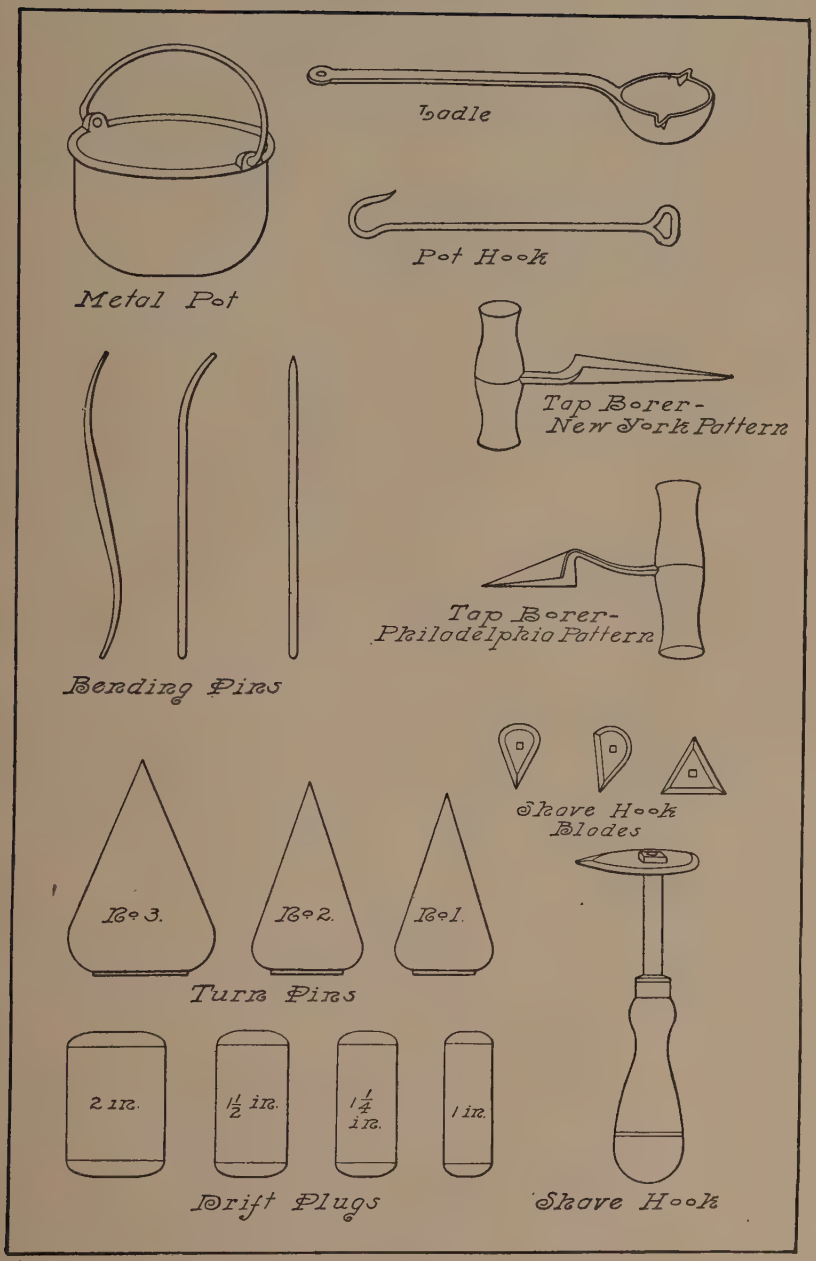


FIG. 1.—A Few of the Plumber's Tools.

of a lead pipe. Such a hole may be made entirely with the tap borer, or it may be started first with a bit. The latter is usually the preferable method, as on heavy lead pipe it is slow work getting the hole started, and so much pressure is necessary that light pipe is in danger of being crushed. The tap borer is made in two styles, the New York pattern being long and sharply tapered, and the Philadelphia pattern short, with a taper less sharp.

Ratchet tap borers are also used to a considerable extent.

Turn pins are necessary in expanding or flaring the ends of lead pipe. The plumber generally requires three sizes, Nos. 1, 2, and 3. Turn pins should be made of boxwood, dogwood, or lignum vitæ.

The shave hook, as its name indicates, is used for shaving off the oxidized surface of lead pipe, in order to obtain a bright surface. This is always a necessary operation, as solder will not adhere to any but a clean, bright surface, free from all oxidation. Shave-hook blades are made in three styles, as shown in illustration—oval, half oval, and triangular.

The selection of the form of shave-hook blade is a matter of taste on the part of the workman, although the oval pattern is probably mostly used.

Drift plugs are used for forcing through lead pipe to take out any dents or uneven places in the pipe, and are made in the diameters of the bores of the several sizes of lead pipe. The material of which drift plugs are made is the same as for turn pins, either boxwood, dogwood, or lignum vitæ.

In Fig. 2 are shown other tools which the plumber commonly uses.

The dresser is a tool used in shaping and smoothing up lead pipe and sheet lead.

Most dressers manufactured and sold are of hard wood, but many plumbers prefer to make their own of soft wood. The soft-wood dresser does not mar the lead as the hard wood does.

The bending of lead pipe is done in several ways, one of which is by the use of sand.

The pipe is filled with sand and the ends securely plugged, after which the pipe at the bending point is heated slightly, in which condition, if the sand is closely packed, a very perfect bend

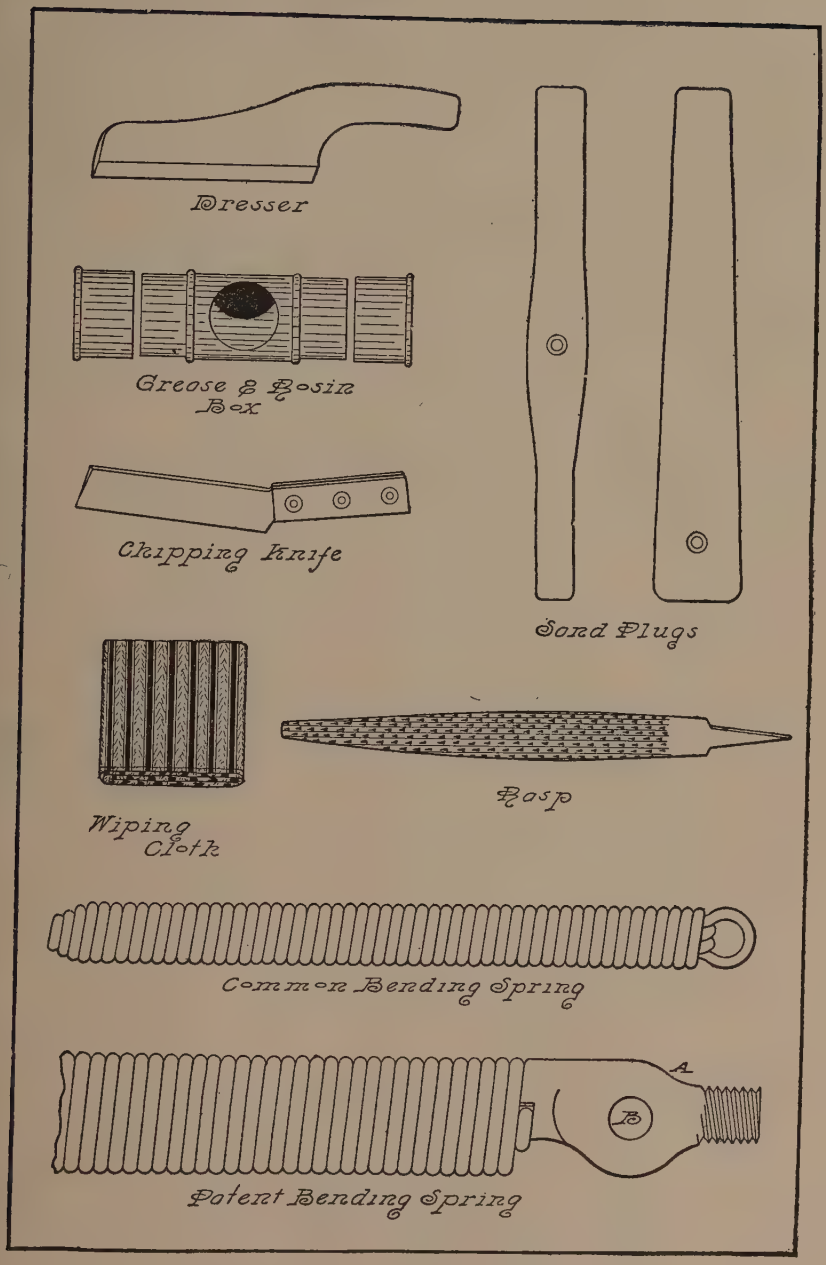


FIG. 2.—A Few of the Plumber's Tools.

may be made. The sand plugs shown in illustration are used for plugging the ends of pipe to be bent in this manner. These plugs are made in two styles, as shown.

The grease and rosin box is a device which is to be found in most plumbers' kits.

When rosin, grease, etc., are not kept in some such receptacle they become scattered among the tools, and are not only hard to find when needed, but adhere to the tools and get them into dirty condition.

The chipping knife is used for chipping off the uneven thin edges of wiped joints.

The upper side of the blade is made thick, so that it may be struck with the hammer.

The wiping cloth is used in making wiped joints. When the molten metal has been poured onto the pipe, and has finally reached the right consistency, the workman works the mass of metal with his wiping cloth into the form of the symmetrical wiped joint.

There are two kinds of wiping cloths, ticking and moleskin. The latter is the more expensive, but not necessarily the preferable style, as ticking wiping cloths are preferred by many plumbers. The best ticking wiping cloths are made of a high grade of herringbone bed ticking. When properly made, a ticking wiping cloth is of 16-ply, that is, 16 thicknesses. Ticking wiping cloths may be folded so that the grain of the cloth will run lengthwise or crosswise of the cloth. Most plumbers prefer their cloths made in the former manner, although many use the cross-grain cloth. In Fig. 3 is shown the proper method of folding wiping cloths, both ticking and moleskin. No. 1 shows the shape and proportions of the cloth from which the wiping cloth shown in Nos. 2, 3, 4, and 5 is to be made. The dotted lines show the creases or folds in the cloth after it has been made up.

No. 2 illustrates the first operation, which consists in folding the two edges of the cloth to the center of the piece of ticking, and No. 3 the second operation of folding from the center to the side. The partly folded cloth is then reversed, as shown in No. 4, and the two narrow ends folded over so that they meet in the center. No. 5 shows the final fold.

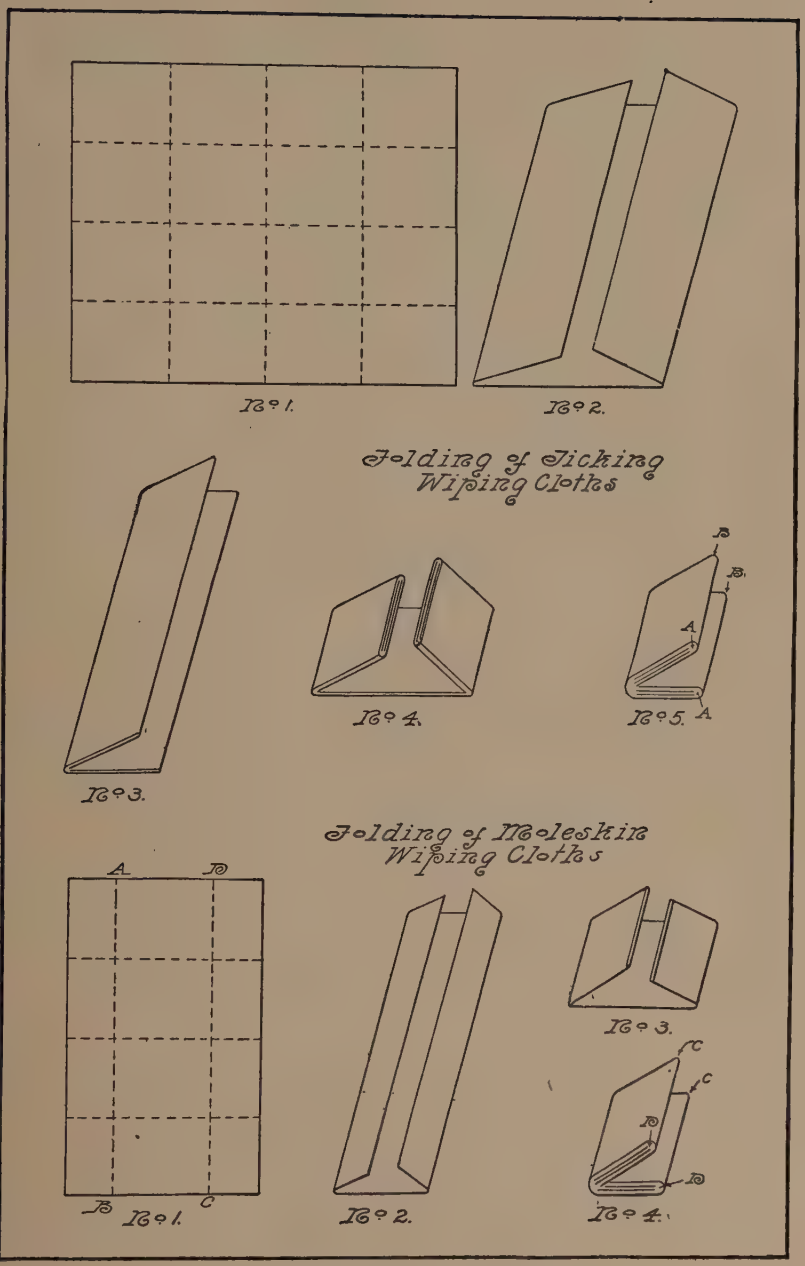


Fig. 3.—The Folding of Wiping Cloths.

After completing the folding, the cloth should be secured at the points A A and B B. This is done by taking several stitches with needle and thread in such a way that the thread is not exposed on the wiping edge.

In Fig. 3, No. 1 at the foot of the page shows the proportions for a moleskin wiping cloth of the same size as the ticking cloth already described. From a comparison of the wiping cloths of the two materials it will be seen that the area of moleskin required is only half that required of ticking.

The reason for this is that the moleskin is so heavy that if made 16-ply it would be too thick. However, in order to give firmness to the cloth, it is well to paste onto it, in folding, one thickness of stout paper. This paper should be of the size and cover the area shown by A B C D. If paper is used, the two sides should be folded over, as shown in No. 2, and the two edges pasted to the paper, and the moisture allowed to dry out under a slight pressure before proceeding with the folding. No. 3 shows the second operation, and No. 4 the third and last, after which the corners of the cloth should be secured as in the case of the ticking cloth.

After completing the number of wiping cloths required, it is a good plan to grease them with hot grease and then put them under a heavy pressure for about twenty-four hours. When this is done they will hold their shape to much better advantage.

Most plumbers use mutton tallow on their wiping cloths, which aids very materially in the working of the cloth in wiping joints, and, indeed, the workman is usually much averse to parting with an old and long-used wiping cloth, as it has become thoroughly saturated with grease, smooth, and free from any fuzz that a new cloth is bound to show. Special preparations are on the market for greasing wiping cloths, which produce excellent results.

To those who make their own wiping cloths the following table of sizes will be of value. In the first column is given the size of the completed wiping cloth, the first-named dimension being that of the wiping edge.

The figures in the second column show the dimensions of cloth to be cut for the several sizes.

Sizes of Ticking Wiping Cloths

Size of Wiping Cloth	Necessary Dimensions of Ticking
4 in. × 4 in.	16 in. × 16 in.
3½ " × 3½ "	14 " × 14 "
3¼ " × 3¼ "	13 " × 13 "
3 " × 3½ "	12 " × 14 "
3 " × 3 "	12 " × 12 "
2¾ " × 3 "	11 " × 12 "
2½ " × 3 "	10 " × 12 "
2½ " × 2½ "	10 " × 10 "
2¼ " × 3 "	9 " × 12 "
2 " × 3 "	8 " × 12 "
1½ " × 3 "	6 " × 12 "

Sizes of Moleskin Wiping Cloths

Size of Wiping Cloth	Necessary Dimensions of Moleskin
4 in. × 4 in.	16 in. × 8 in.
3½ " × 3½ "	14 " × 7 "
3¼ " × 3¼ "	13 " × 6½ "
3 " × 3½ "	12 " × 7 "
3 " × 3 "	12 " × 6 "
2¾ " × 3 "	11 " × 6 "
2½ " × 3 "	10 " × 6 "
2½ " × 2½ "	10 " × 5 "
2¼ " × 3 "	9 " × 6 "
2 " × 3 "	8 " × 6 "
1½ " × 3 "	6 " × 6 "

The quarter- and three-quarter-inch sizes are not standard sizes, and therefore not generally carried in stock, although many plumbers claim that they must have cloths of these odd dimensions. It is difficult to name any complete set of wiping cloths, as one plumber will often require different sizes than another workman, and also because of the variation in size of joints made in different sections of the country.

Ordinarily, however, a set of wiping cloths complete enough for the workman would include the following cloths: 4 in. × 4 in., 3½ in. × 3½ in., 3 in. × 3 in., 2½ in. × 3 in., 2 in. × 3 in., 1½ in. × 3 in., the latter being of the flange pattern, with the rounded wiping edge.

To return to Fig. 2, the rasp shown is a necessary tool in the work of the plumber.

This should be an ordinary coarse wood rasp, and is used for such purposes as beveling or tapering the ends of lead pipes.

In recent years the bending of lead pipes has been largely accomplished by the use of bending springs, instead of by the old-time methods which were not only slow but required a considerable amount of skill.

These springs are made to fit into the bore of the lead pipe, when the latter may be bent without danger of collapsing, after which the spring may be withdrawn.

These springs are often damaged in withdrawing them from pipes, owing to the fact that attempts are sometimes made to pull them out. The spring should be wound up, thus decreasing its diameter sufficiently to allow its easy withdrawal. Turning the spring so that it unwinds is a very bad practice also.

Recently a patented bending spring has appeared on the market, which has several features which make it superior to the common spring. The spring is firmly secured to a malleable iron head A, as shown in Fig. 2, this head being provided with a hole B, and at its end with a half inch pipe thread. Through the hole a piece of pipe may be thrust, and used as a lever to wind up the spring in withdrawing it. A half-inch pipe may be screwed to the end of the spring, and by means of it, withdrawn from the pipe after the bend has been made. This attachment allows a bend to be made at any distance from the end of the pipe, whereas in the use of the common bending spring, any bend made at a distance from the end of the pipe greater than the length of the spring, could be made only with much difficulty and waste of time.

The hammer is a tool concerning which the plumber is usually very particular; especially in his use of it in calking cast-iron pipe. In Fig. 4 are shown several styles of hammer used by the plumber. The hammer shown in No. 4 is generally advertised

as a plumber's hammer, but is not used so extensively as the other styles shown, which are known as machinist's hammers. Nos. 1 and 2 are very commonly used. No. 3 has the advantage of having the same face on either end, which is regarded as a desirable feature by many workmen, as the hammer never needs to be turned around to get the striking face in the right position. Hammers are made in the following weights: 1 lb., 1¼ lb., 1½ lb., 1¾ lb., 2 lb., 2½ lb., and 3 lb., the weight usually being marked on the end of the handle. This weight is exclusive of the handle. The 1-lb.

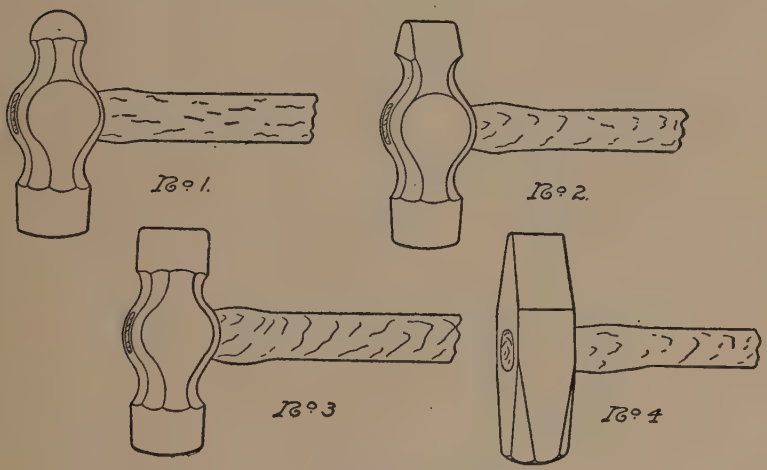


FIG. 4.—Plumbers' Hammers.

hammer is too light for the plumber's use; the 1¼-lb. weight is about right for calking, although 1½-lb. hammers are often used; 1½-lb., 1¾-lb., and 2-lb. hammers are used for cutting extra heavy pipe. The plumber ordinarily requires two hammers: one for calking and another for cutting. The heavier weights of hammers are used chiefly in the calking and cutting of large extra-heavy cast-iron pipe on water mains, and similar heavy work.

Calking tools, which are indispensable to the plumber, are tools concerning which he is especially particular. Each workman generally has his own particular ideas as to the calking tools that meet his desires. So true is this, that many workmen have their calking tools made to order, instead of obtaining tools ordinarily carried in stock.

These tools are made in great variety, and the workman who does his work to best advantage must be provided with a considerable number of them, most of which are designed for use in special places, or under special conditions.

These tools may be obtained ground for inside or outside calking.

In Fig. 5 are to be seen various styles of calking tools, some of which may not have been previously seen by all of our readers.

The plumber's cold chisels are of numerous variety, ranging from an 18-in. brick chisel to very small styles.

B represents a blunt cold chisel much used in cutting soil pipe, which is not so easily gotten out of order as the thinner and sharper chisels, such as A. C, D, and E represent different styles of regular calking tools, having blades of different lengths and thickness. F is known as a throat iron, and is very useful in calking such fittings as bends, where there is little room for a direct blow. G and H represent right- and left-hand offset calking tools. It often happens that lines of soil pipe are run in corners, and it is clearly seen that tools of this description are very useful in calking the part of the joint that is on the back side of the pipe. K is another tool for the same purpose.

L is a picking-out chisel, used in picking out the lead of a calked joint, its shape being such that the work may be done to advantage.

M is a stub-calking iron with which almost a direct blow can be given, and of greater force than can be gotten with the regular calking irons, as there is no springing of the tool.

N and O represent yarning irons, the former stiff, and the latter having a spring blade. They are used in forcing the oakum into place, one tool being preferred by some workmen, and the other by others. P is known as a ceiling iron, and is used in calking joints in such positions that a downward blow cannot be delivered in the usual manner. A joint very close to the ceiling, for instance, may be made with this tool, the blow of the hammer being delivered on the offset near the handle.

W, in Fig. 6, represents a special form of yarning iron, having but one offset, which many workmen find preferable to other styles.

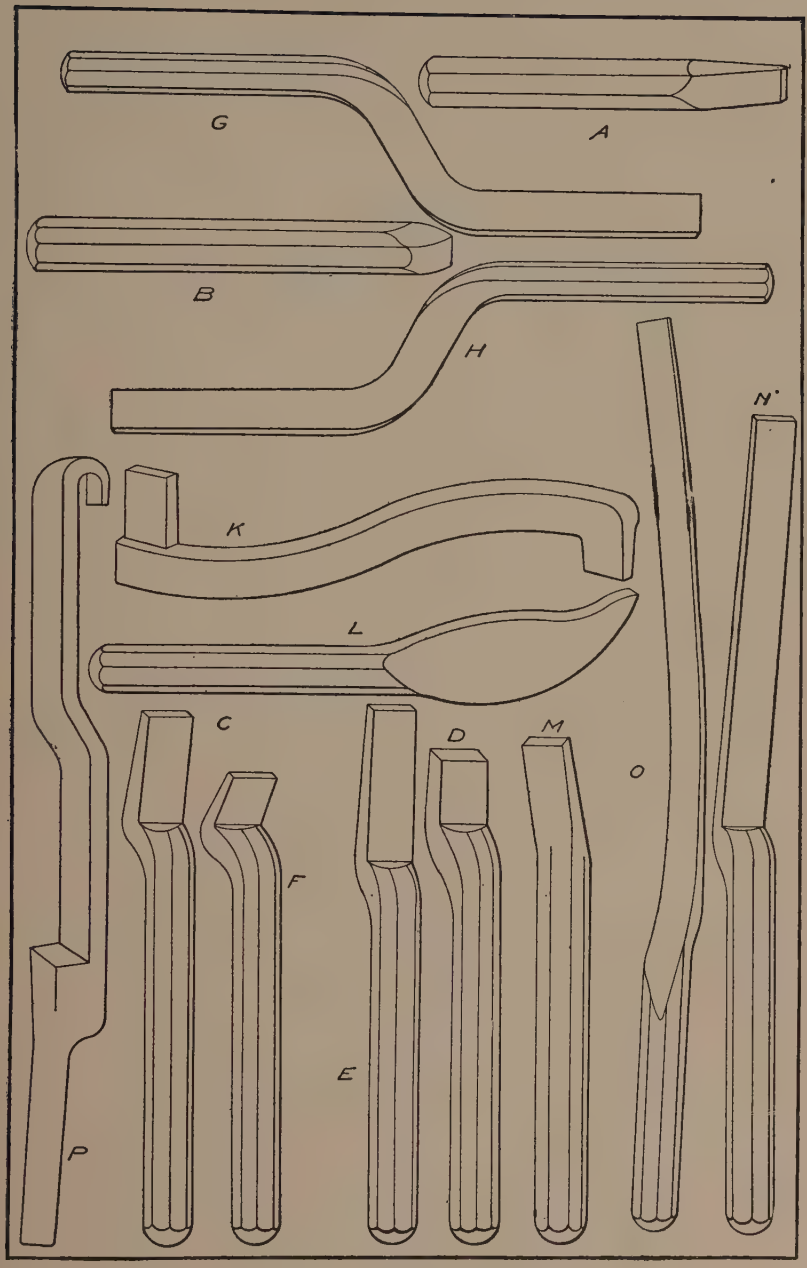


Fig. 5.—Various Styles of Calking Tools

The other tools in this illustration are special forms of chisels, which will be found very useful to the plumber.

R is a hammer head chisel and S a hammer head gouge, both of which are used in such work as cutting through floors, timbers, etc., and should be ground and tempered to withstand as well as possible the striking of nails and similar rough usage.

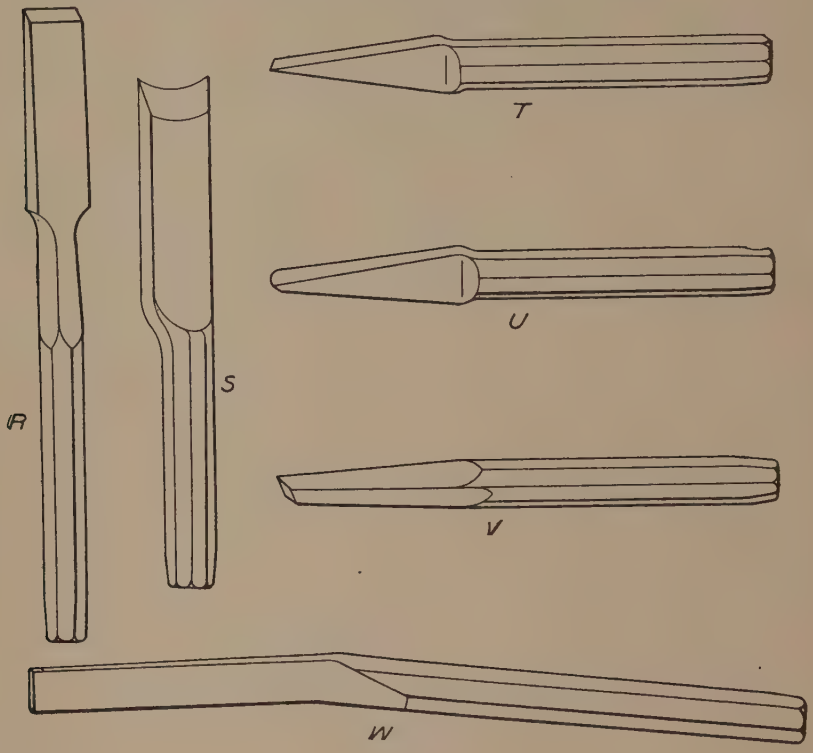


Fig. 6.—Special Plumbers' Chisels.

These tools will be found preferable for hard usage to the common wooden-handled chisels. The three tools shown by T, U, and V, are respectively cape and half-round cape chisel, and diamond point chisel.

A very important feature in the making of calking tools is the forming of them in such a manner that they shall be rigid under a blow, with as little spring as possible. In offset tools, for instance, the offset should be as straight as possible, as a sharp

offset will make the tool spring, and often render it unfit for use. This is one of the chief objections to calking tools handled by most jobbers of such goods.

There are many other varieties of special calking tools and chisels which might be mentioned, but those already described constitute the principal types of such tools.

In Fig. 7 are shown several special plumber's tools, some of which are of comparatively recent origin, while others have been in common use for many years.

The 5-wheel lead pipe cutter is a tool well-known and highly valued. The only point against it is that it will not cut larger than 1½-inch pipe. This is a point which the 4-wheel cutter shown in the illustration overcomes, a point of considerable importance nowadays, as the use of two-inch pipe is constantly increasing, as it is a size which is being more extensively used on waste lines for such fixtures as kitchen sinks, laundry tubs, etc.

The lead pipe expanding pliers is a tool which has been devised to do the work of the several sizes of turn pins. By pressing the lever handles together, the conical end opens and spreads the pipe. The end of the cone is knurled, which tends to prevent the expanding cone from slipping out of the end of a heavy pipe in expanding it.

It will be seen that as the cone opens, it forms an ellipse instead of a true circle, and to make the expanded end of the pipe perfectly round, the expander must be constantly turned as it is being used.

The asbestos joint runner is a most valuable tool to the plumber, although, strange to say, there are many plumbers who do not possess the tool, and still adhere to the old methods of using clay, putty, oakum, etc., in making calked joints.

As the illustration shows, the asbestos rope is wound around the pipe, both ends bent back, and secured by the clamp, allowing a triangular opening into which the metal may be poured. On vertical joints the use of the joint runner is not necessary, but on horizontal joints it is of great service in preventing the escape of the molten lead when it is poured into the hub.

The brass pipe wrench is to-day a necessity with the plumber who desires to put up neat brass and nickel work. As shown in

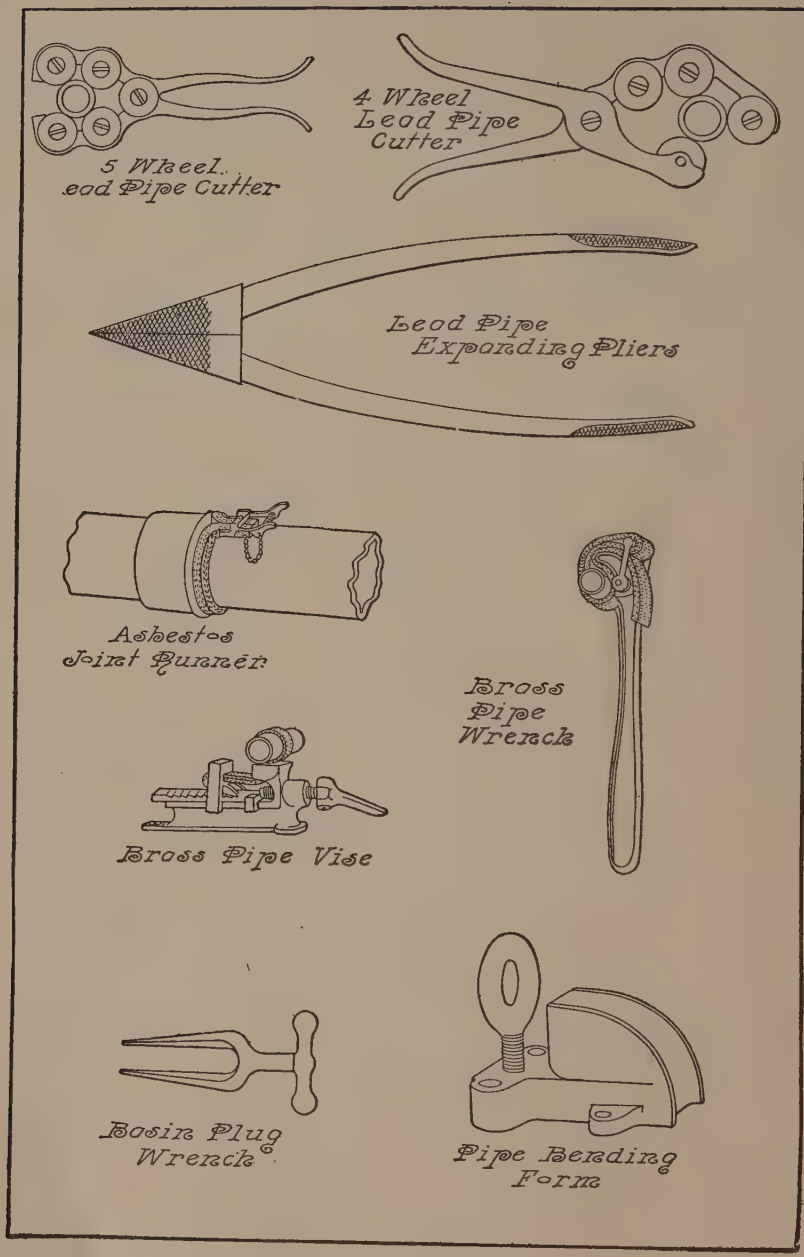


Fig. 7.—Plumbers' Tools for Special Purposes.

illustration, the wrench is arranged for brass tubing, the curve in the head of the wrench preventing the crushing of the tubing. When being used on brass pipe, the strain comes on the nose of the wrench or near the point. The grip is made by means of a stout band or strap made of heavy ducking, by means of which a powerful grip may be secured without marring or scratching the pipe, as would result in the use of a common pipe wrench. To make the strap work properly, it should be rosined.

The brass pipe vise operates in a similar manner by the use of a rosined strap of ducking. When such a vise is not at hand, brass and nickel pipe may be held without scratching by means of

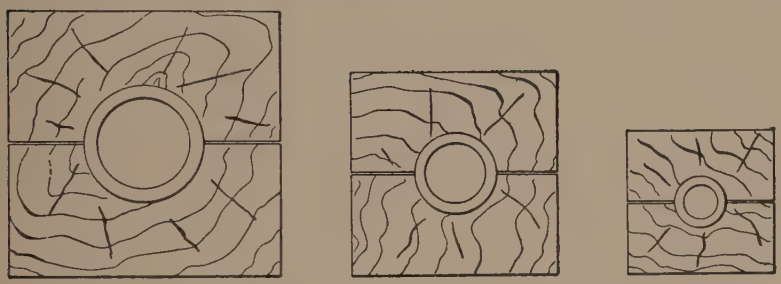


Fig. 8.—Wooden Vise Blocks for Holding Brass Pipe.

wooden blocks, as shown in Fig. 8, a separate block being used for each size of pipe.

These blocks may be made by boring a hole of the right size through a split block, and then planing the surfaces that come together slightly, so that the surfaces will not meet when held in the vise.

The basin plug wrench is a simple but very handy device. It is used for preventing the turning of the bowl plug of a wash basin when the locknut underneath is being set up, and also for holding the plug when it is to be disconnected. The plumber often has trouble in holding the plug from turning, and in many cases has been known to use his dividers to do the work of the wrench, usually springing and otherwise damaging them.

The pipe-bending form is of cast iron, screwed to the work bench or to a plank, and is used in making bends on wrought iron,

brass, and lead pipe. By adjusting the eye bolt to the work, the bending may be easily accomplished.

There are many tools which the plumber usually has in his kit, or the employer owns, which are not shown in the accompanying illustrations. Most of the fundamental and most necessary tools have been shown, however, and briefly described, and at various other points certain other tools will be mentioned.

CHAPTER II

WIPING SOLDER—ITS COMPOSITION AND USE

Solder, such as used by the plumber, is composed of lead and tin.

The proportions in which these two metals are used vary considerably with the use to which it is to be put.

The plumber requires both bright solder and wiping solder, the proper consistency of the latter being a matter of great importance to him in the making of wiped joints. Bright solder is made of one part lead and one part tin.

The proportions for wiping solder are not so definite as for bright solder, as different workmen are accustomed to different degrees of fineness in their wiping solder. In general, however, the proportions may be laid down as three parts of lead and two parts of tin. Ten parts of lead and six parts of tin is a proportion sometimes used. Many of the best workmen make their own wiping solder, such a course enabling them to obtain solder that is suited to their individual requirements.

Nothing but the purest grades of lead and block tin should be used.

A test used by some plumbers to prove wiping solder, is to pour a small quantity of the melted metal onto a cold surface, when, if it is of about the right quality, it will have when cool a mottled appearance.

If it is too coarse—that is, if it has too much lead, it will have a granular appearance. If it is too fine—that is, if it has too much tin, it will have a very bright appearance.

While lead melts at about 612 degrees and tin at 442, the melting point of wiping solder is about 450 degrees, and of bright solder about 375 degrees.

There are certain substances which act very injuriously to wiping solder.

For instance, the presence in a pot of wiping solder of a very small amount of zinc, will make it entirely unfit for use.

Antimony and iron are also injurious.

The greatest amount of trouble, however, arises from the presence of zinc, for this metal is used extensively in the manufacture of plumber's brass work, such as bibbs, ferrules, nipples, solder unions, etc., and in wiping these fittings onto lead pipes, more or less of the zinc is taken up by the solder. This is especially true in the use of the cheaper grades of ferrules and nipples, which often contain large amounts of zinc. It is a customary practice of the plumber to dip his brass work into the wiping solder, in order to tin it, and this is one of the quickest ways in which the solder may be spoiled.

The experienced plumber can usually tell very quickly whether there is zinc in his wiping solder, as it works up roughly and crystallizes in a different manner than good solder. Solder is also often damaged by carelessly overheating it. This burns out the tin and leaves the solder coarse.

When impurities are known to be present, the solder may be purified in the following manner: Heat the solder red hot in the first place. If the solder is heated so as to appear red hot in the light, it is too hot, and should be heated only so that it shows a faint red in the dark. When this heat has been reached, throw into the solder a lump of sulphur, which will mix with the impurities of the solder when it is stirred, and carry them to the surface. Any oxidized tin or lead formed in overheating will also separate out in the form of a powder and rise to the surface. The impurities should be thoroughly skimmed off with the ladle, and after the solder has somewhat cooled, it is well to throw in some tallow, which will liberate the sulphur, and also a lump of rosin, which will further improve it.

After this refining process has been completed, the metal will usually be too coarse, owing to the burning out of some of the tin. Therefore the solder should be tempered with new metal until it has regained its right consistency.

When wiping solder is being used it should be stirred occasionally, in order to thoroughly mix the lead and tin, for the latter being the lighter, tends to rise to the top.

CHAPTER III

JOINT WIPING

The art of making wiped solder joints is acquired only by experience, and written instructions concerning the subject amount to but little. To be able to make the various forms of wiped joints in a perfect manner is the ambition of the young plumber, and it may be said that comparatively few actually reach a high standard in this branch of the work.

In modern plumbing construction the use of lead and solder is very limited, for the reason that the employment of lead for nearly all purposes in plumbing construction has been replaced by the use of other materials.

Indeed, the use of lead is now very largely confined to short lengths of lead waste and vent pipe, and in a great deal of work no lead whatever is used. This is a great change from the conditions that obtained years ago, when the older plumbers of to-day were working at their trade. In those days, all traps, bends, etc., and even soil pipe, were made of lead, and made by the workman himself. In addition, lead was used entirely for the lining of tanks; lead safes were extensively used, and a large amount of ornamental lead work was constructed. It is not strange, therefore, that skill in the manipulation of lead and solder has declined greatly in recent years, and indeed, it may be said that the skill in this line of work formerly required is no longer a necessity.

The reason for the use of the wiped joint is that this form of joint is stronger than other forms, and presents a better appearance.

The wiped joint should be symmetrical, both to secure uniform strength and neat appearance. The two illustrations shown in Fig. 9, show poorly constructed joints.

Wiped joints are made in a variety of shapes and sizes. In some sections of the country, it is customary to wipe a short, thick

joint, while in others, long, thin joints are made. Joints excessively long or excessively short are unsatisfactory. If solder is to be economized, it is better to make the saving in length, rather than in thickness, for a short, thick joint has greater strength than a long, slender joint. The strength of a wiped joint depends not only upon the amount of solder used, but upon the quality of the solder. A joint may be well wiped and of symmetrical shape, and

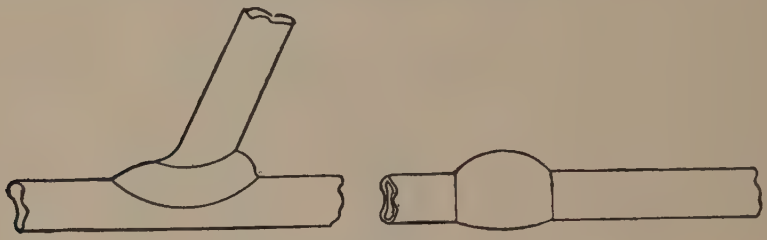


Fig. 9.—Poorly Shaped Wiped Joints.

still be a poor joint, owing to its being porous. When porous, the joint will "sweat" as it is termed, that is, drops of water will ooze through the solder. This is caused by the poor condition of the solder, due usually to a lack of the proper amount of tin. Solder when made of the proper proportions of lead and tin is much stronger than the lead, and it is the tin that gives the solder its strength by cementing the mass of metal together.

In Fig. 10, several kinds of wiped joints are shown, also the method of preparing the lead pipes which are to be joined together by the joint.

The simplest joint is the round joint of Nos. 1 and 2. This joint may be wiped upright or underhand, that is, horizontally.

Nos. 1 and 2 in Fig. 10, show two different methods of preparing the pipe. In No. 1 the female end of the pipe is prepared with the tap borer or the rasp. If the latter is used, care should be exercised to prevent the inside of the pipe from being roughed up by the striking of the end of the rasp against it. The male end is then rasped off to fit the female end.

In the case of No. 2, which is preferable to No. 1, the female end is flared out with the turn pin, the inside surface being shaved to give a clean, bright surface. It is essential that the two surfaces

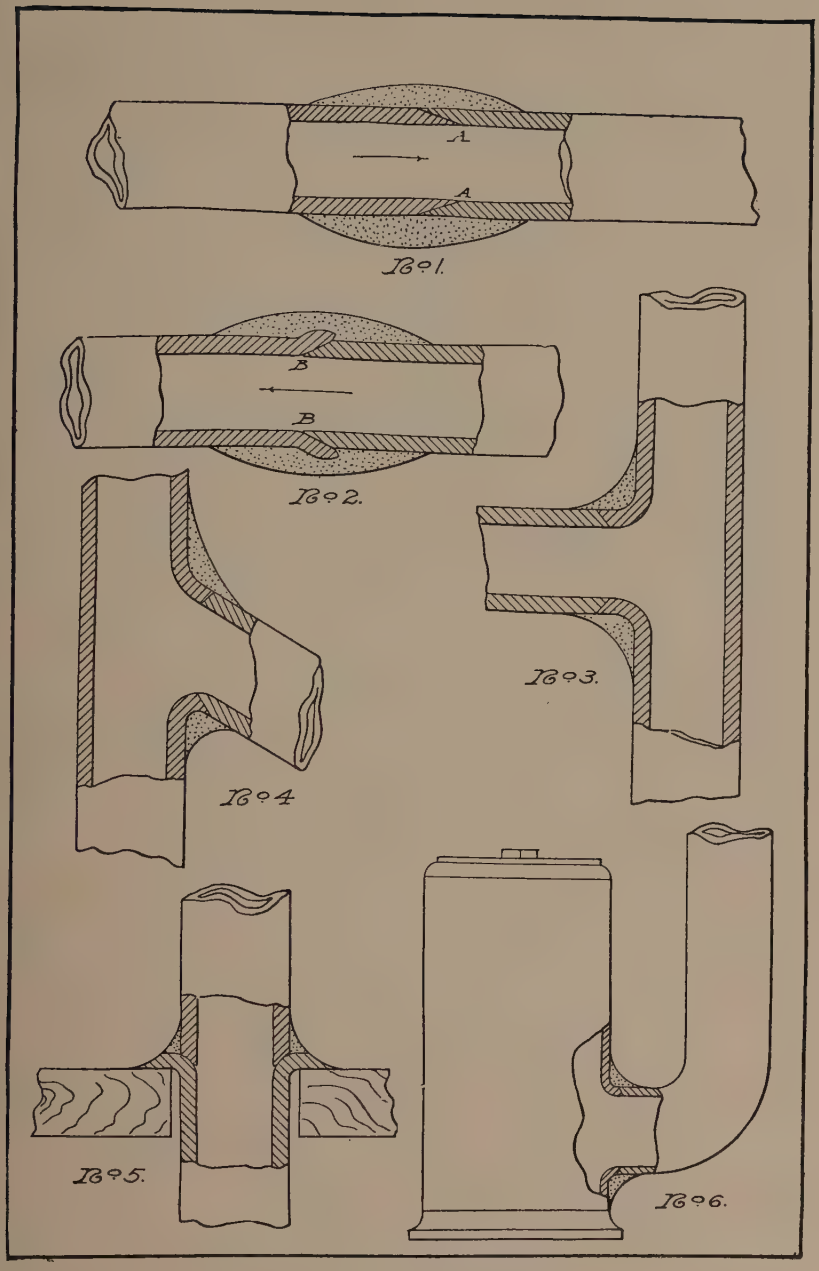


Fig. 10.—Wiped Joints.

that fit together should be bright and free from all tarnishing, in order that the solder may adhere and make a perfect joint between the two pipes.

The next step is to shave off the surface of each pipe lengthwise, as far as the joint is to extend, this being done with the shave hook.

All burrs or rough edges should be made smooth. A very important feature is to join the two pipes together in such a way that anything flowing through the pipe when it is in use, shall have the least possible opportunity to catch on the inside or male end.

Thus, in Nos. 1 and 2, any lint or other material in the waste, would have less opportunity to catch at A A and B B if flowing in the direction of the arrows, than if flowing in an opposite direction. In making a perfect joint, the solder should be able to penetrate into the joint between the two pipes, but it should not be allowed to penetrate into the interior of the pipe, where it would form in sharp points which would catch and hold matter flowing through the pipe.

Before the joint is ready to be wiped, the surface of the pipe beyond the joint and on both sides of it, should be protected, so that the solder may not adhere to it at any point beyond the joint. This may be done in several ways. The universal, old-style method was by means of soil, the soil being allowed to remain on the pipe after the work was completed, it being considered ornamental. The use of soil is practiced to quite an extent even now, but its use is decreasing. Soil is made of lampblack and glue, and when properly made, should stand the following test: Apply the soil to a piece of lead pipe, and allow it to dry. If the lampblack rubs off, it shows too much of this material. If, when the pipe is bent, the soil cracks and breaks off, it shows too large an amount of glue. It may be tempered to stand both these tests.

Fig. 11 shows a round joint and a branch joint set up, ready for wiping, with soil applied.

Another method of preventing the adhesion of solder outside the joint, is by means of paper pasted onto the pipe. The paper covers the same surfaces that are shown covered with soil in Fig. 11. In the case of the round joint it is a simple matter to put on the papers, but in branch joints and other joints of irregular shape,

it is often a difficult matter to cut the paper in the proper shape. Another disadvantage in the use of this method is that sometimes the paper is poorly pasted, or poor paste is used, and the solder works under and sticks.

The most up-to-date method, and one which is being rapidly adopted by plumbers, is the use of plumber's paste. This paste when heated, forms a sort of enamel coating over the surface of the pipe. It bakes onto the pipe and does not flake off, protecting the pipe perfectly and being easily washed off when the work is complete. Only specially prepared paste will answer for this work,

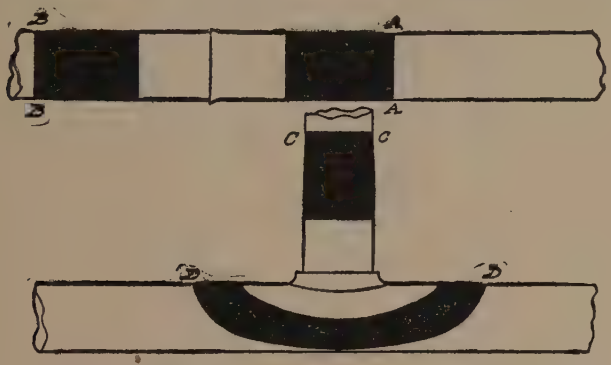


FIG. 11.—Joints Prepared with Soil, Ready to be Wiped.

as common pastes will cook and flake off. The use of paste for this purpose accomplishes good results with less labor than either soil or paper. In the use of soil, it is applied before the pipe is shaved. Referring to Fig. 11, it will be seen that the soil must be applied to make a sharp line at A A, B B, C C, and around the outer curve D D, but inside these lines it may be applied without care, as these surfaces are to be shaved.

The round joint, the preparation of which has been described, is now ready to be set up and wiped. A common method of holding the work in position for wiping is shown in Fig. 12. The plumber will often support his work on bricks, and hold it in position by means of them, and, indeed, many workmen prefer this method to the use of special devices for this purpose. There are many devices on the market, however, designed to hold the work in position, one of these being shown in Fig. 13. In wiping a

branch joint, a third pipe holder may be used to hold the branch pipe in position. The use of the pipe holders will be clearly seen. They are driven into the work bench or into a plank, and by means

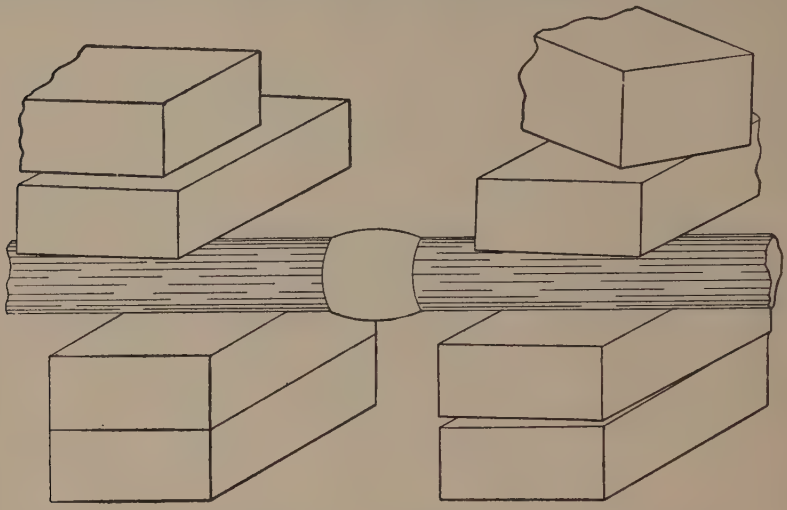


FIG. 12.—A Common Method of Holding Pipes for Wiping Joints.

of the slotted upright piece the work can be held at any height or at any desired angle. There are no bricks or other obstructions to

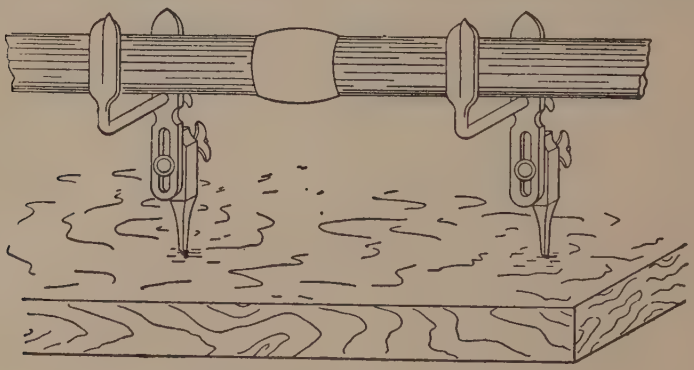


FIG. 13.—Use of Pipe Holders in Wiping Joints.

get in the way of the workman, and there is less liability that the work may become dislodged.

As already stated, it is an impossibility for the novice to learn

the art of joint wiping from books. He must practice under the direction of some person who understands such work. There are certain suggestions which can be made, however, which will be of much value to the beginner. After the work has been set up, place a large piece of paper underneath it to catch the solder. The next thing is to be sure that the solder is at the right heat. A very good method of testing it, is to thrust into the molten solder a shaving or a piece of paper rolled up.

If the shaving or paper takes fire, the metal is too hot, but if the material chars quickly, the solder is right to use. Some experienced plumbers can tell the condition of the solder by holding the ladle in the solder until it is of the same temperature, and then quickly holding it to his cheek. This test, however, requires experience. When sure that the solder is at the right heat, take the ladle in the right hand and fill it about three quarters full.

Pour the solder onto the joint very lightly at first, so that it may not burn through.

Move the ladle backward and forward, pouring over the entire surface, and even out beyond the joint at either end, in order to heat the pipe thoroughly, and to a temperature of the same degree as the solder. This is a very important part of the work, cannot be hurried, and is a point not often fully appreciated by the beginner. Continue pouring, and with the catch cloth in the left hand under the joint, catch the solder as it falls off, and throw it back onto the joint.

Gradually the solder becomes soft yet firm, and when it has reached this condition, get the joint roughly into the shape required. Then, quickly laying down the ladle, take the wiping cloth in the right hand and form the joint as desired. It is almost useless to attempt to explain this last operation.

Some workmen use two wiping cloths in wiping a joint, while others use only one.

A very important point is to wipe the thin edges quickly, as the metal cools at these points almost immediately, and if this is allowed to happen, a good joint cannot be wiped. When the joint is nearly formed, attention must be given especially to the bottom of the joint. The heat of the joint will usually cause the solder to run off at this point, and the workman must with his cloth, pre-

vent this, and prevent the joint from getting out of shape at this point. While the solder is being poured onto the joint and the latter is being brought to the right heat, the wiping cloths should be heating, so that when needed they shall not be cold.

If the solder sticks to the cloth, it shows that there is too much tin in the solder.

If there is too much tin the solder will tend to run off from the bottom and make it almost impossible to wipe a perfect joint. It

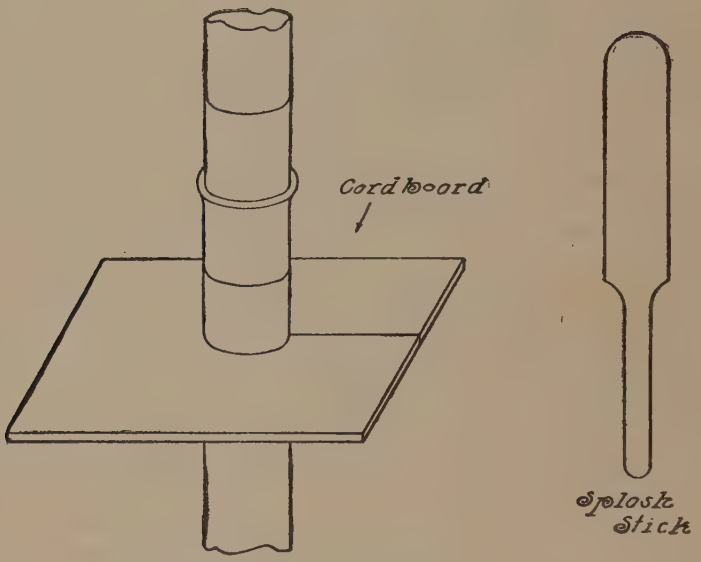


Fig. 14.—Wiping of Upright Joints.

is well to rub onto the cloth a little whiting or powdered chalk to prevent scratching. It is also necessary to grease the cloth with tallow, which makes it work more smoothly, and acts as a flux for the solder. Grease should also be applied to the lead work as soon as it has been shaved, in order to prevent the surfaces from oxidizing. This action takes place quickly after the lead is shaved, and prevents the proper adhesion of the solder to the lead, as it forms a thin coating between them.

A small trowel will be found very handy for gathering up the solder that collects under the joint.

It is necessary to give a few suggestions concerning the wiping

of upright joints, for wiped joints must often be made in this position. In Fig. 14 is shown an upright joint set up and ready for wiping.

Below the joint something should be arranged to catch the solder falling from the joint. The method shown in Fig. 14, consists in the use of a sufficiently large piece of cardboard, fitting closely to the pipe and cut through to the edge, as shown, in order that it may be slipped on. This cardboard may rest on any support that may be conveniently used. Another means sometimes used consists of a funnel-shaped lead collar fitting closely about the pipe and close under the joint, collecting the solder in the manner of a saucer. It is claimed that having this collar close to the joint allows the metal to heat up the joint at this point effectually, and to hold the heat.

In making an upright joint, unless the workman is skillful in pouring the metal from the ladle, it will be necessary to have what is known as a splash stick, which is illustrated in Fig. 14, with which to throw the solder onto the joint.

The plumber may make his own splash stick out of any piece of wood at hand.

It should be about 6 or 7 inches long, $\frac{1}{8}$ inch thick, and $1\frac{1}{4}$ inches wide in the wide part. In getting the solder onto the joint, splash the solder onto the upper part of it and all around it.

With the splash stick keep pulling the solder up onto the upper part of the joint.

When the solder has reached the right consistency and amount on the joint, shape it roughly with the splash stick, then wipe it quickly with the cloth. In all wiping work, the secret of successful work is quickness without any lost motions.

Attention may now be given to the wiping of branch joints, as shown by Nos. 3 and 4 of Fig. 10. With the gimlet or tap borer open the pipe at the point where the joint is to be wiped, being careful not to rough up the inside of the pipe opposite the opening.

The hole should be made smaller than the final requirement, and the lead then beaten out with the bending pin into the form of a collar, the inside of which should be beveled off to receive the end of the branch.

Next bevel the end of the branch pipe to fit into the collar. By

the way, in getting the pipes ready for wiping, before anything else is done the pipe should be drifted out with the drift plug and dressed, so that it is in perfect condition. After fitting the pipes, apply soil or plumber's paste, as the case may be. If the latter is used, go over the work with fine sand paper before applying it.

After the paste or soil has been applied, scribe out the shape of the joint with the shave hook, then with the same tool shave off the surfaces that the joint is to cover.

A word of caution is necessary concerning the use of the shave hook. It is necessary only to remove the oxidized surface and thus thoroughly clean it, and entirely unnecessary to cut deeply into the lead. If a deep shave is made, the strength of the lead at this point will be much impaired. As soon as shaved, the joint should be thoroughly covered with tallow. The work is now ready to be set up and wiped. If pipe holders are not used for supporting the work, various methods may be used for holding the branch in position, depending largely on the location of the work and the conveniences at hand. Generally the branch may be supported against a wall or other vertical surface, or if long, it may be bent around to any convenient support and afterwards straightened.

The flange joint, as shown in No. 5 of Fig. 10, is the most easily wiped of the several joints.

It is used where the pipe passes through the floor or through a wall. The pipe coming through the floor should be of sufficient length above the floor to be flanged over. A good method is to cut a hole in a piece of paper of sufficient size, slip the paper over the pipe, and allow it to rest on the floor to collect the solder dropping from the joint. Flange the lead pipe over onto the floor, beating it down smoothly. In flanging the pipe, use the turn pin to turn it over as far as possible.

The edge of the flanged lead may be left as it is, or may be shaved to a sharp edge, as shown in No. 5. If the latter method is followed, it should be shaved before being flanged over. The soil or paste should next be applied, and the surfaces shaved as already described for other joints. After the flange has been wiped, the paper may be cut out around the joint, so that it does not show. It is a good plan, by the way, in using soil or paste, to apply it

inside the pipes, so that the solder may not run through into the inside of the pipe any more than possible.

No. 6, Fig. 10, shows a lead pipe wiped onto a trap. There is no different principle employed on this work than in making the branch joint in No. 3. In turning out a collar on the trap, to receive the pipe, care must be taken that the side of the trap is not collapsed, for many traps are now made of such thin material that

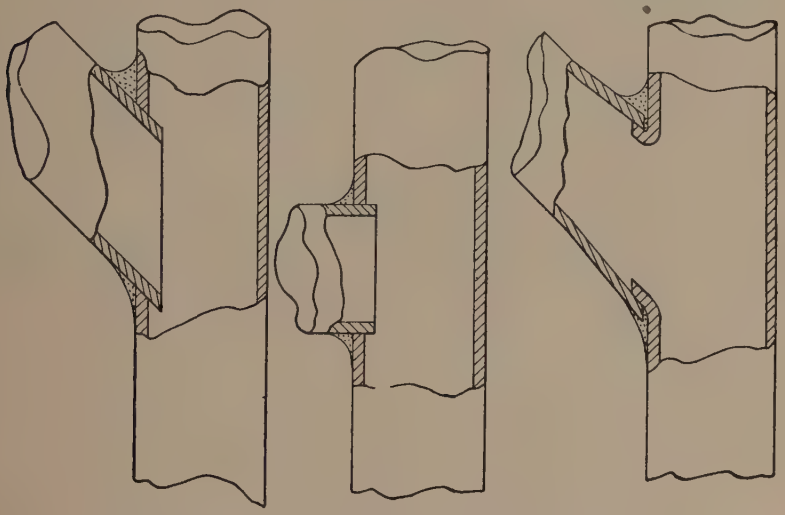


FIG. 15.—Wrong Methods of Making Wiped Joints.

any rough usage is liable to produce this result. The use of the lead pipe expanding pliers will be found satisfactory for such work.

In Fig. 15 are shown three joints prepared in a very poor and unworkmanlike manner. In the first place, no branch should project inside a pipe as it not only cuts down the available area of the pipe, but also presents a serious obstruction in the pipe. In one of the branch joints shown, the branch is fitted around the outside of the collar. This is a very poor practice, as it allows the end of the collar to form an obstruction which, especially in the case of waste pipes, is liable to catch threads and other similar materials in the waste, producing final stoppage. This difficulty could be somewhat lessened by beveling the inner edges of the collar, although such work is wrong under any conditions.

When the branch is fitted as shown in two of the illustrations,

solder has a much greater opportunity of working into the pipe than in work properly constructed.

It will be noted, also, that the amount of solder used on the joints in Fig. 15 is insufficient to afford the necessary strength to the joint.

As to the proper length of wiped joints, the practice varies greatly. For the smaller joints, however, a length of from $2\frac{1}{4}$ to $2\frac{1}{2}$ inches makes good looking work, and about $1\frac{1}{2}$ inches for a 4-inch joint.

Thus far, attention has been confined solely to the wiping of

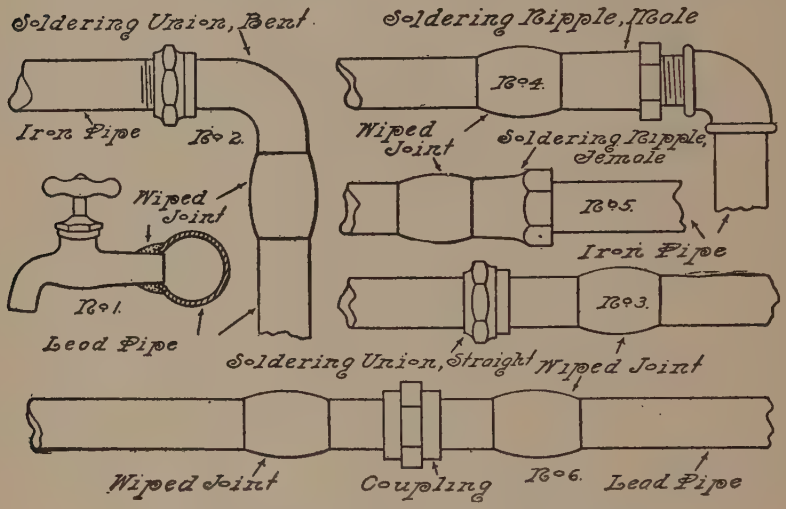


FIG. 16.—Wiping of Brass Work onto Lead Pipes.

two lead pipes together. In addition to this there is a great variety of work such as shown in Fig. 16, that is, work in which lead pipe is wiped to various pieces of brass work. There is comparatively little to be said on this subject, as the principles employed are not different from those already considered.

In wiping bibbs, soldering nipples, unions and couplings onto lead pipe, the pipe is flared at the end with the turn pin, and properly shaved. The brass piece is then set into the cup thus formed, and the lead beaten down to the brass. As far as shaving, soiling or pasting and greasing, the work is the same as that already considered. Before the brass work is ready to be set up and wiped,

however, the end to which the joint is to be wiped, must be well tinned. The brass end is first filed off until a thoroughly clean, bright surface is obtained, and it is then tinned with a copper. This is a much better method than the common one of dipping the brass into the pot of solder, which always results in leaving in the solder more or less zinc which is present in the brass. The flux used in tinning brass work may be either rosin or tallow, or some prepared wiping flux. The latter is usually put up in boxes in the form of a paste, an advantage in its use being that it does not get

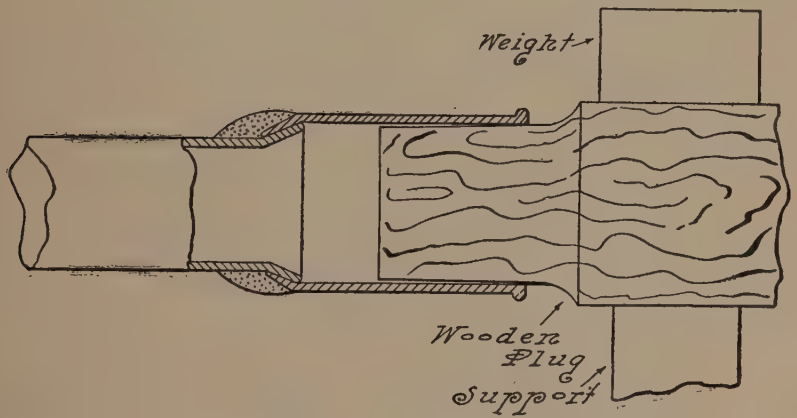


FIG. 17.—Supporting of Brass Ferrule for Wiping.

onto the tools as rosin or grease does, which is kept loosely in the plumber's bag.

The wiping of brass ferrules is a very important feature, though bringing into use no additional principles.

In Fig. 17 is shown the ordinary method of holding the ferrule in position for wiping. A wooden plug of the desired length is driven into the hub end of the ferrule, and this may be supported either by the pipe holder or on any convenient support with a weight to hold it in position.

Several different forms of brass ferrules are shown in Fig. 18, and the various methods of preparing them for wiping.

Ferrule No. 1 is of the tapered pattern, the pipe fitting inside it. No. 2 is of the straight pattern, the pipe being swelled out at the end with the turn pin until it just fits the inside diameter

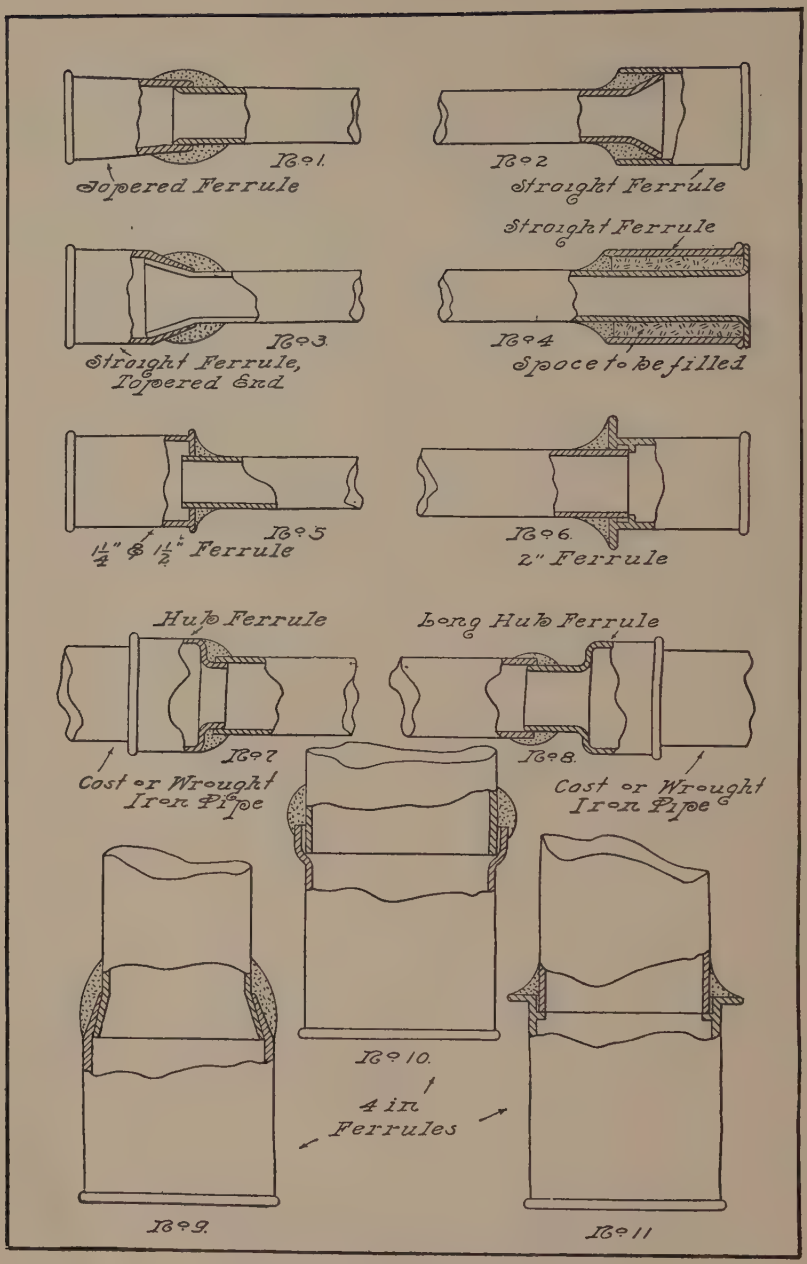


FIG. 18.—Wiping Brass Ferrules.

of the ferrule. If the inside of the ferrule is thoroughly brightened, this makes a strong joint. No. 3 ferrule is a common pattern, with the pipe turned over to fit the taper of the ferrule, the joint being round. In these three connections, if the pipe were fitted outside, the end of the ferrule would present a shoulder which would act as an obstruction. Such a method would be considered very poor practice.

The method shown in No. 4 is an excellent one. The space between the pipe and the ferrule may be calked with paper.

Nos. 5 and 6 show a new form of ferrule in which a flange joint may be used. The flange joint is not only the easiest to prepare and wipe, but less solder is used on it than on the ordinary joint. In order that a flange may be obtained, the ferrule for 2-inch pipe must be cast somewhat different than the ferrule for $1\frac{1}{4}$- and $1\frac{1}{2}$-inch pipe.

Nos. 9, 10, and 11 show 4-inch ferrules of different patterns. No. 11 is of the same general pattern as Nos. 5 and 6, a flange joint being used.

The 4-inch ferrule is usually wiped upright. It is a difficult joint for the beginner, the chief difficulty being in getting the work up to a proper heat. To facilitate this, the ferrule may be heated over a fire, or a bag of hot sand may be laid inside of it.

The glazing of wiped joints should be considered before leaving the subject. As soon as the joint has cooled just sufficiently to be firm, a ladle of semifluid solder is poured onto the joint, and as quickly as possible wiped off. If the metal is too hot it will melt the joint and destroy its appearance. Glazing must be done at exactly the proper time or it will not be successful. A glazed joint looks very bright and is unlikely to be porous.

If it is desired to give the wiped joint a mottled appearance the workman should blow upon it while it is cooling, and some workmen in blowing spit upon the joint with a sort of spray.

In addition to wiped joints, there are two other common joints, the cup joint and the overcast joint.

The cup joint is made very simply, by swelling the end of the pipe by means of the turn pin, setting the end of the other pipe into the cup, and filling the latter with solder by means of the soldering copper.

While this joint is not allowed on the plumbing system as a general thing, it is often used in connecting bowl cocks to lead supplies.

The hatchet copper may be used to advantage in making the cup joint, as it swivels and may be used on the back side of the pipe more handily than the common soldering copper.

The overcast joint is made in the shape of the wiped joint, but with the soldering copper. Most plumbing ordinances prohibit its use, as well as the use of the cup joint, but on work not regulated by ordinance, each is used to quite an extent.

The overcast joint may be rasped and filed into such form that it has an appearance similar to that of the wiped joint.

As previously stated, the making of wiped joints is a matter of considerable skill, gained by experience, and it may also be added that unless the workman keeps in practice, he loses the ability to do the work easily and well, although he soon regains the skill that he has lost.

CHAPTER IV

LEAD WORK

Plumbers' lead work has changed greatly within the last twenty-five years.

In the first place, there is not nearly so much of this work done at the present time, different methods are used for constructing the work, and furthermore, whatever lead work is used on the plumbing system is now nearly all manufactured in such form that it is ready for use without the necessity of being worked up into shape by the plumber. Twenty-five years ago, most of the tanks used on the plumbing system were lined with sheet lead, whereas sheet copper has now quite generally taken its place. Occasionally, however, tanks are required to be lined with lead, and the method of lining with lead is a subject which the plumber should understand, even under the conditions that exist to-day. In the following remarks relative to the lining of a tank with sheet lead, the instructions for laying out the sheet metal itself, apply equally to either lead or copper.

The roll of sheet lead, which should generally be either 4-lb. or 6-lb., should be laid upon the floor, and with the assistance of his helper, the plumber unrolls it, until it lies flat upon the floor. With his dresser the plumber should then go over the sheet lead, taking out all dents, creases, etc. After being thus worked upon, it is ready to be laid out to fit the tank.

In Fig. 19 is shown a perspective view of a tank, the dotted lines showing the lining, each corner being lettered. In Fig. 20 is shown the method of laying out the sheet, whether of lead or copper, for the tank shown in Fig. 19. It will be noted that the lettering of the respective surfaces in the two illustrations correspond. C E F D is laid out the same size as the bottom of the tank. A C D B and E G H F of the same size as the sides, and A C E G and D B H F of the same size as the ends. The measurements

F H, E G, A C and B D should be cut about an inch longer than the height of the tank, by the way, in order that this extra length may be turned off and tacked to the upper edges of the tank.

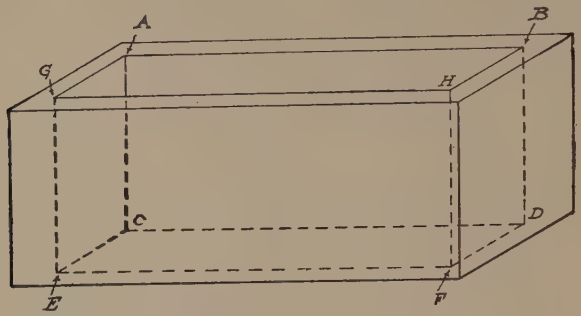


FIG. 19.—Lead or Copper Lining for Tank.

The two sides should be cut about two inches longer than the length of the tank, in order that these strips may be formed around the corners of the tank, to act as a support to the lining, and to

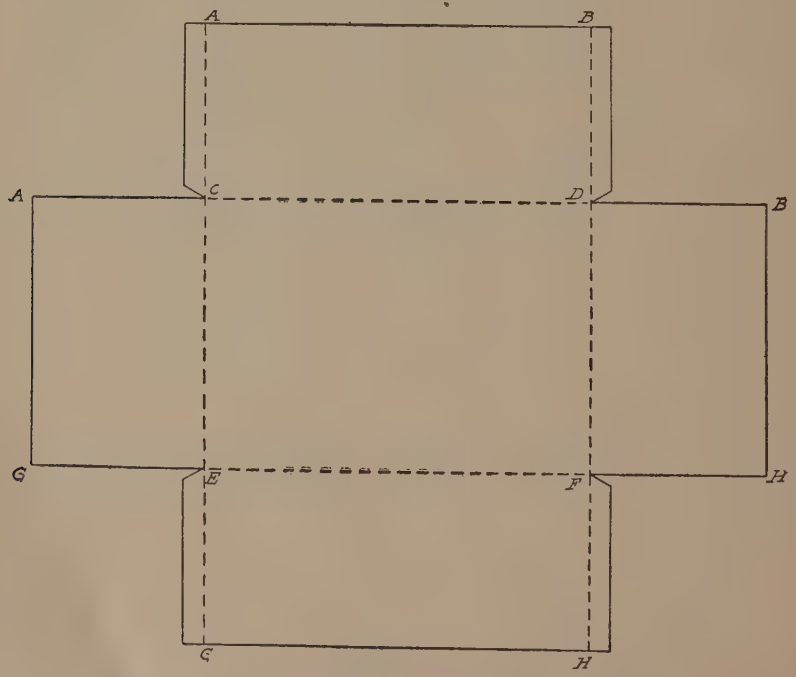


FIG. 20.—Layout of Lead or Copper Lining for Tank.

prevent the solder from flowing in between the lead and the sides of the tank. These strips should be secured to the ends of the tank with copper nails.

The dotted lires in Fig. 20 show where the lining is to be bent to fit into the tank. In placing the lead in the tank, it should be folded so as to be easily handled, but with as few sharp bends as possible. After being placed in the tank, the lead sides are gradually worked up into place. The strips left on the corners should be securely fastened, and the corners of the lining driven back into place with a wooden wedge. After the lead has been driven into place, and the small corners on the top edge of the tank filled with a piece of sheet lead, the work is ready for scraping, in preparation for the wiping of the seams. A line should be drawn to establish the width of the joint. Then with the shave hook, proceed to scrape the surface, being careful to make a clean-cut edge and not go over the line. When the scraping has been completed, go over the brightened surfaces with tallow or plumber's wiping flux. The joints or seams are now ready to be wiped.

From ½ lb. to 1 lb. of solder should be figured on per foot of seam, according to the size of the tank. On this work a tool known as a plumber's iron is generally used, its purpose being to keep the work heated up. A piece of board should be cut out to fit into the corner at the bottom of the tank, to catch the falling solder. Next take a ladleful of solder in the left hand, and with the splash stick in the right hand, commence to throw the solder onto the seam, shoving it back into place with the splash stick, and taking it from the board at the foot of the seam. Continue this until the work is well tinned, and at the proper heat. When the work has reached this condition, drop the ladle and splash stick, taking the iron in the left hand and the wiping cloth in the right. Pass the iron, which has been previously heated, gently over the surface of the solder, to keep it properly heated, and with the wiping cloth wipe down from the top, a quarter or less of the length of the seam. Do not try to do too much at a time. After getting well started a longer strip can be wiped.

In wiping the seam, the heat is quite likely to cause the sheet lead to leave the wood and rise up, but this can easily be pressed back into place with the cloth.

When near the bottom, plunge the point of the iron into the solder to limber it up, and with the cloth remove the surplus solder. Next remove the board, and finish the joint in the lower corner. While the plumber's iron is generally used, there are some expert plumbers who can wipe a seam without its use. It requires much practice, however, to attain this degree of skill, and, as a rule, the iron is used. The old-style storage tanks were so heavy, especially after the lining had been set in place, that it was difficult to turn the tank over on its side. Therefore the seams were generally wiped upright. At the present time most of the tanks whose seams would have to be wiped upright are tanks used for special purposes, such as acid tanks in factories, etc.

Whenever small tanks are to be lined with lead, the present custom is to turn the tank onto its side and solder the seam with an ordinary soldering copper.

Seams on copper tanks may be wiped or soldered, although, as in the case of lead, such seams are now generally soldered.

A very effective method of supporting a lead lining on the

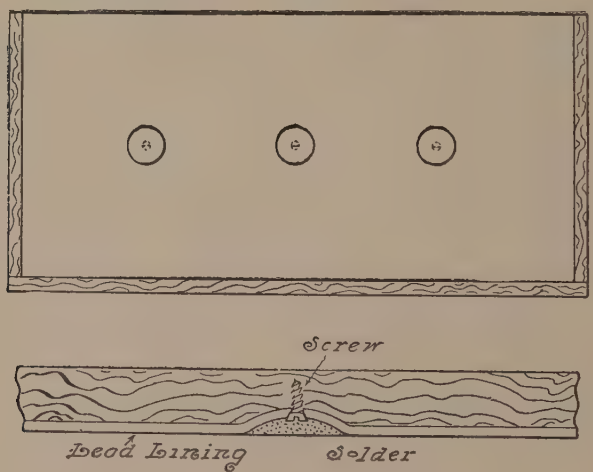


Fig. 21.—Supporting of Lead Lining on Sides of Tank.

sides of a large tank may be seen in Fig. 21. On large tanks special support is necessary, as the lead is soft and very heavy and liable to creep on the vertical sides. This method consists in cutting out a number of shallow bowls in the sides of the tank, the

number depending on the size of the tank. These bowls may be made with a carpenter's gouge. After the lead is in place, beat it into the bowls with a round-faced hammer or mallet, and secure the lead to the sides of the tank with a screw, as shown in the detail view in Fig. 21. These bowls should then be scraped bright and covered with tallow. Then, with the splash stick, throw the solder into the bowl in the same manner as for an ordinary joint. When the metal is ready for wiping, wipe the bowl quickly, leaving its surface flush with the lead lining. This covers the head of the screw, and makes a strong and permanent support for the heavy lead sides, which otherwise would be liable to sag in time.

In addition to the subject of lead linings, there is also something to be said regarding the running of lead pipes. The bending of lead pipes was considered to some extent in the chapter on plumbers' tools.

Too much importance cannot be attached to the proper supporting of lead pipe.

Lead is a peculiar metal, and deteriorates much more rapidly if improperly put up, as is well known by the older lead workers. Lead in time seems to lose its life and grow rotten, and has not the sustaining strength that it has when new. Again, lead under heat becomes soft, not that its atoms expand in bulk to the extent that occurs in some other metals, but when heated, the atoms making up the body, under a slight expansion readily slip by each other. It is due to this action that a piece of lead pipe will bend more readily when heated than when cold. For this reason, great care should be exercised in the running of lead pipe, that it be well supported, in order that its own weight may not cause it to sag. The sagging of lead pipe carrying hot water is more common than the sagging of cold-water pipes. Very often lead pipe which is supported only by clips will be found supported at intervals of three and four feet. While such work as this looks good when new, it will be but a very short time before the pipe will have a wavelike appearance throughout its entire length, due to the sagging of the pipe between its supporting points. The sags will often cause the pipe to dip two or three inches from the horizontal. The sagging of lead pipes not only makes a very unworkmanlike piece of work, but such pipes cannot be entirely drained, water always remaining

in the sags to freeze and burst the pipe in the event of the vacancy of the premises during cold weather. In addition, such sags, when they occur on hot-water pipes, interfere with, and often entirely interrupt the circulation of hot water.

To be well supported, clips should be placed every eighteen inches on a horizontal line. This will result in good work, work which will retain its proper alignment for many years. One of the best methods of supporting horizontal lines of lead pipe, and a very easy method, is to nail up strips of board and run the pipe on the edge of the board. Suppose, for instance, that the pipe is to be run under a floor. The plumber would naturally arrange the work as far as possible so that the pipes would follow the timbers

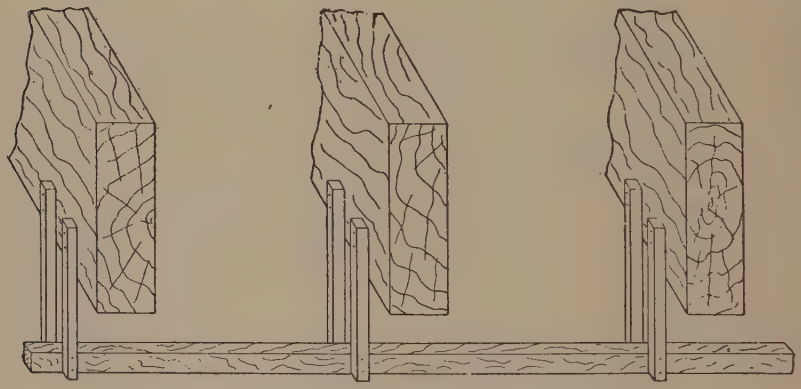


FIG. 22.—Support for Horizontal Line of Lead Pipe.

through the spaces rather than cross the timbers. The latter method often requires much cutting and consequent weakening of timbers, and there is also the possibility of sagging between timbers. When conditions are such that the pipes can follow along the timber, nail narrow strips of board to the side of the timber, giving the strips such pitch as would be required for proper drainage. The pipe should be run on the upper edge of this strip, supporting it with clips as often as is necessary to hold it from slipping off. This, of course, does not need to be often, as the clips do not in any way support the weight of the pipe.

Work run in this manner will look as well, and be in as good condition ten years after being installed as at the time it is put up,

provided the proper weight of pipe has been used to withstand the existing pressure.

A modification of this same idea can be applied to pipes run horizontally in the cellar. Suppose a single line of lead pipe is to be run through the cellar. Take strips of board, furring strips, for instance, supporting these strips to the timbers above, as shown in Fig. 22, and shortening the supports in order to give the pipe its proper pitch. A very good idea is to run a line through the cellar, to serve as a guide in securing the proper pitch.

When a number of pipes are to be run side by side, as is often required, let the board selected be of sufficient width to hold the desired number of pipes, and the same means of support described above may be used.

This makes an excellent support, and not only are the pipes always protected from sagging, but in the event of repairs, the workman has simply to mount his steps, when he can look directly down upon all the pipes, select the one on which he wishes to work,

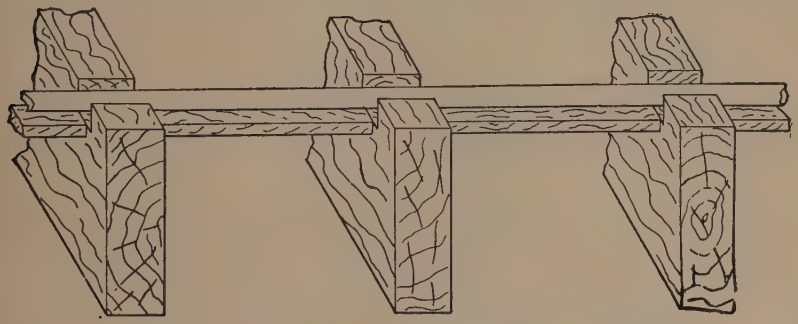


Fig. 23.—Supporting of Lead Pipe between Timbers.

and many times complete the necessary repairs without removing the pipe from its position. Any moving or bending of pipes on repair work should be avoided whenever possible, as the pipe will always stretch more or less, and get somewhat out of shape.

When pipes must be run across timbers, instead of in the direction in which the timbers run, the method shown in Fig. 23 may be used to give support to the pipe between timbers. This method consists simply in nailing strips of board between the timbers, on which the pipe may rest.

An objection to using metal clips in supporting lead pipe is that, owing to the softness of lead, the clip will work into the pipe, sometimes sufficiently to weaken the pipe to a considerable extent.

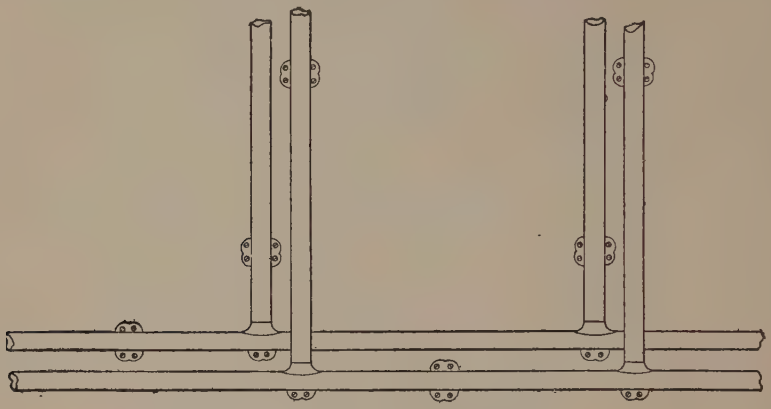


Fig. 24.—Use of Lead Tacks.

This result is due to the weight of the heavy lead pipe coming upon the clips. Lead tacks, soldered to the pipe and screwed to the support, are also much used on lead supply work, both on concealed

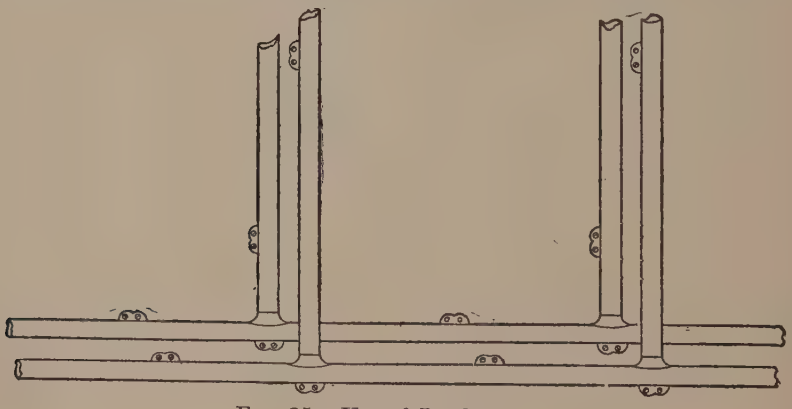


Fig. 25.—Use of Lead Tacks.

and on exposed piping. The use of lead tacks is shown in Figs. 24 and 25.

In Fig. 24 they are shown in pairs, and in Fig. 25 singly and alternately on opposite sides of the pipe.

These tacks are used on both horizontal and vertical lines of lead pipe.

As already stated, lead pipe is not now used to the extent that it formerly was, but has now been replaced by galvanized wrought iron and brass.

In many respects this change is for the best. While the plumber is unable to display the skill in installing pipe of other kinds than lead, wrought iron and brass are free from many of the evils that accompany the use of lead pipe.

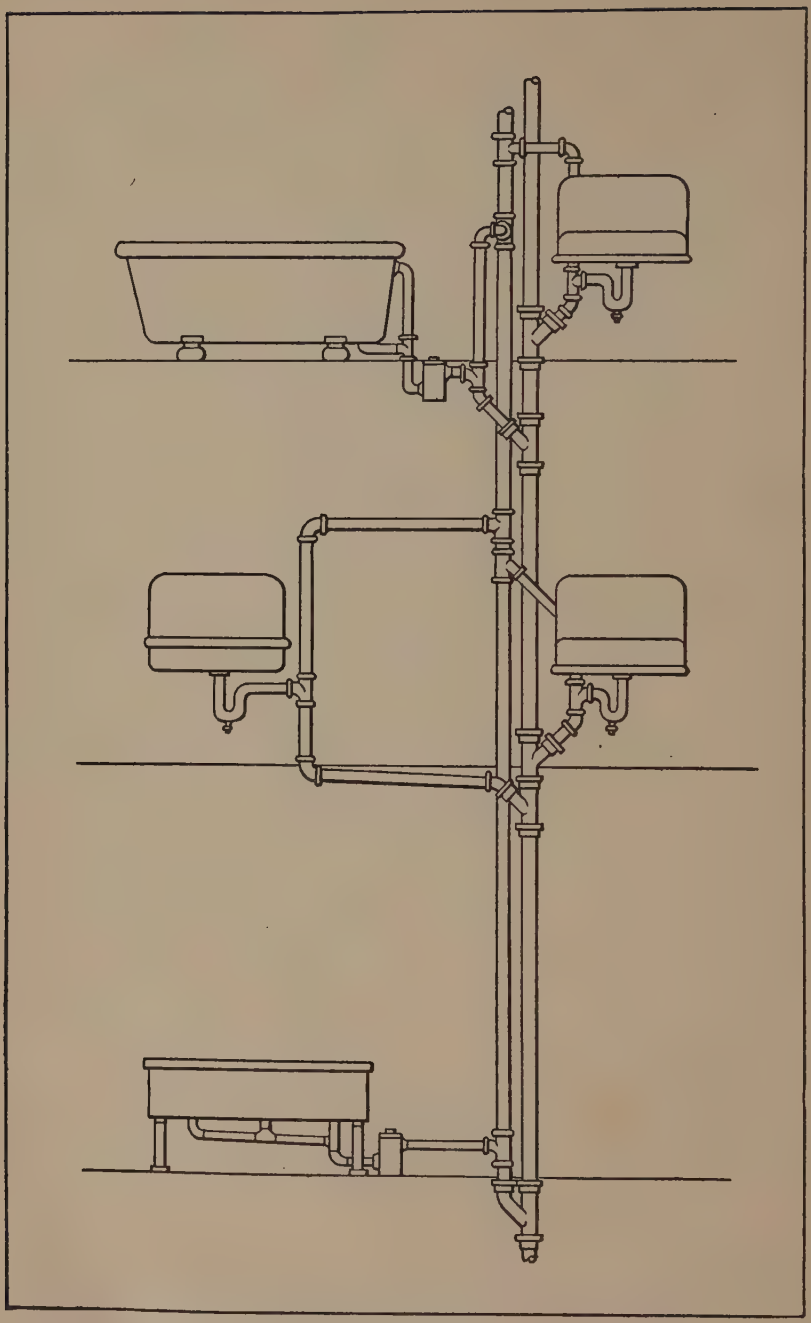


Fig. 26.—Traps and Connections for a Line of Fixtures.

CHAPTER V

TRAPS

The subject of traps is a fundamental one, inasmuch as upon the proper operation of the trap depends the operation of the entire plumbing system, from a sanitary standpoint.

Defined, the trap is a vessel holding a quantity of water, whose purpose is the prevention of the passage of gases and odors from the sewer or cesspool, and from the plumbing system itself, into the house.

In order to protect the house from such danger, a trap is required not only under each plumbing fixture, but also on each floor drain, cellar drain, rain leader, etc.

The use of traps under the various fixtures, and their connections, is to be seen in Fig. 26. The subject of venting, which is so closely associated with trap work, will be considered in another chapter.

It may be said that all traps used in plumbing construction are based upon one or the other of two fundamental types. These are shown in Fig. 27, the two types being known as the S trap

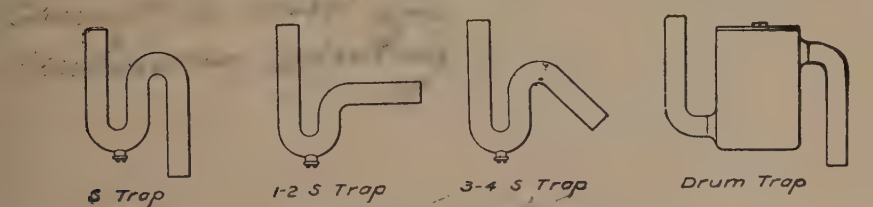


Fig. 27.—Fundamental Types of Traps.

and the drum trap. These two forms of trap are more commonly used than any others, and concerning their comparative excellence there has long been much debate. By many the S trap is considered the best form of trap, inasmuch as it is self-scouring and therefore more easily kept from becoming foul. The chief argument against the S trap is the fact that it may easily lose its seal

by siphonage, such action resulting in establishing direct communication between the sewer and the interior of the house. The characteristics of the S and drum traps are exactly opposite; where one is weak the other is strong. The drum trap holds a large body of water, a large part of which is inactive. Therefore it is not to be expected that this form of trap will be so free of filth as the S trap; in fact its opponents claim that the drum trap is in the nature of a small cesspool. On the other hand, the drum trap is far less liable to siphonage than the S trap, a 4-inch drum trap being found by test to be practically nonsiphonable under conditions generally existing in the plumbing system.

In the use of these two forms of traps a neutral position would appear to be more logical than the radical position so generally

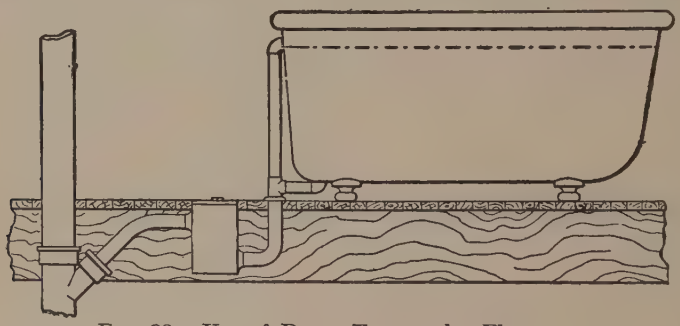


FIG. 28.—Use of Drum Trap under Floors.

maintained by the plumbing fraternity, there being places where either one will certainly do better work than the other. For instance, when vented and used in connection with such fixtures as lavatories, also in the construction of water-closets, main traps, etc., the S trap is the better and more convenient form to use, for while holding the advantage of being self-cleansing, its size in many of these instances, and the size of its connecting pipes, eliminates almost entirely the danger of siphonage. Many times it is essential that to insure perfect work, the delivery from the trap should be as rapid as possible, and it can readily be seen that delivery from the S trap more nearly satisfies such requirement than the delivery from the drum trap. On the other hand, the drum trap is especially well adapted to use beneath floors, for instance, in bath-tub work, Fig. 28 showing such a connection.

As a rule, the waste pipe from such a fixture as the bath tub has none too much fall, particularly when the trap is at some distance from it. Under such conditions a better pitch can be secured in the use of the drum trap, and in addition, the cleaning facilities are much better in the case of the drum trap. Another point which recommends the drum trap is its great depth of seal, this being an important feature of the trap, particularly if attached to a fixture not often in use, for with a shallow seal evaporation soon breaks it.

Although not considered the best practice, it often happens that two or more fixtures enter the same trap, as for instance, bath and lavatory, or sink and laundry tubs, and when so installed the drum trap is almost a necessity, as its construction allows several waste pipes to enter it at different points at the bottom, while a pipe of larger size from the top forms the outlet.

From these two traps scores of other traps have sprung into existence. In the illustrations shown in Fig. 29 will be found various forms of these traps now in common use. There are traps which have valves of one kind or another. In general these valves are very simple, consisting usually of a ball resting against a seat, the ball being displaced when waste enters the trap, and reseating itself after the waste stops running. In these traps, which also have the ordinary water seal, dependence is made for additional protection upon this valve or mechanical seal as it is called. When new, such a trap may do good work, but the trap soon becomes foul, and the valve likewise, in which condition it not only fails to perform its work, but becomes actually an obstruction around which substances may collect and eventually form a complete stoppage of the trap. Most plumbing ordinances now prohibit the use of this class of traps. There is another class of traps having one or more partitions within the body of the trap. Such traps usually have the advantage of being compact, convenient for use in many places, and make a neat appearance. However, when such internal partitions project above the water line in the trap, danger is always present, from the fact that sand holes or other imperfections may exist, under which condition direct communication with the sewer is established. A particularly bad feature of such partitions is that serious flaws may exist, and remain

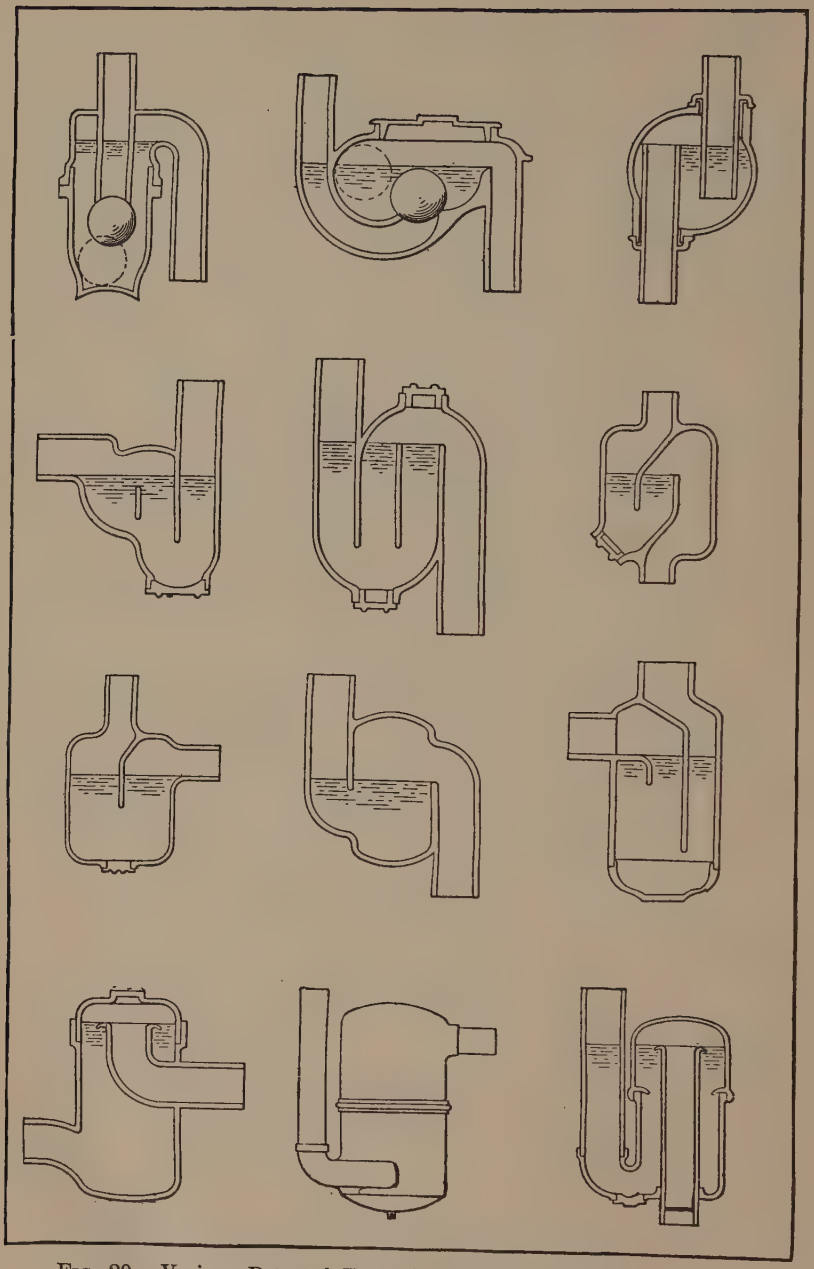


Fig. 29.—Various Patented Traps in More or Less Common Use.

undetected, for whatever leakage may come from them shows only inside the trap, never outside. If it could be detected from the outside the faulty trap might be replaced, thus obviating the continuance of the resulting danger for an indefinite length of time. Many ordinances now discriminate against this form of trap.

There is also a class of traps so constructed as to give the waste in passing through it a centrifugal motion. This result is obtained by connecting the inlet into the trap on a tangent instead of into the center. This causes the waste to take a whirling and lifting motion. This trap is made in the form of the drum or round trap, but while possessing very great scouring and self-cleansing properties, it is liable to lose a portion of its seal, due to the momentum acquired. Thus, many different classes of traps might be named, each presenting some feature that would appear of value. Many of these features have much merit, especially when the trap is new, but when put to the test of time under actual working conditions, many apparently excellent traps have either failed entirely or only partially achieved the results claimed for them.

In Fig. 30 may be seen several additional forms of traps. Each of these traps is of patented form, having advantages and disadvantages which the reader may discern after having followed the foregoing remarks on trap construction.

It will be noted that two of the traps shown in Fig. 30 are specially adapted to use under floors, and have the advantage of a cleanout accessible without the removal of flooring. The trap constantly being sought for, and which may some day be brought out, should be simple in construction, self-cleansing, nonsiphonable, have a good seal, and no internal partitions, depend upon no mechanical device, and have as few corners or places where filth may collect as possible. In addition, facilities must be provided for the cleaning of such a trap. Although there are many excellent traps now on the market, it does not appear that perfection has yet been reached, and therefore until such a trap does appear, the present forms must be used, and judgment exercised in deciding which form is best adapted to the special work in hand. For the past few years there has been much money and energy expended by manufacturers in the attempt to produce a trap that would be non-

siphonable, siphonage, by the way, being the greatest obstacle to the attainment of a perfect trap. Many times the manufacturer has flattered himself that the desired result had been reached, and in many cases has been successful in convincing city health officials

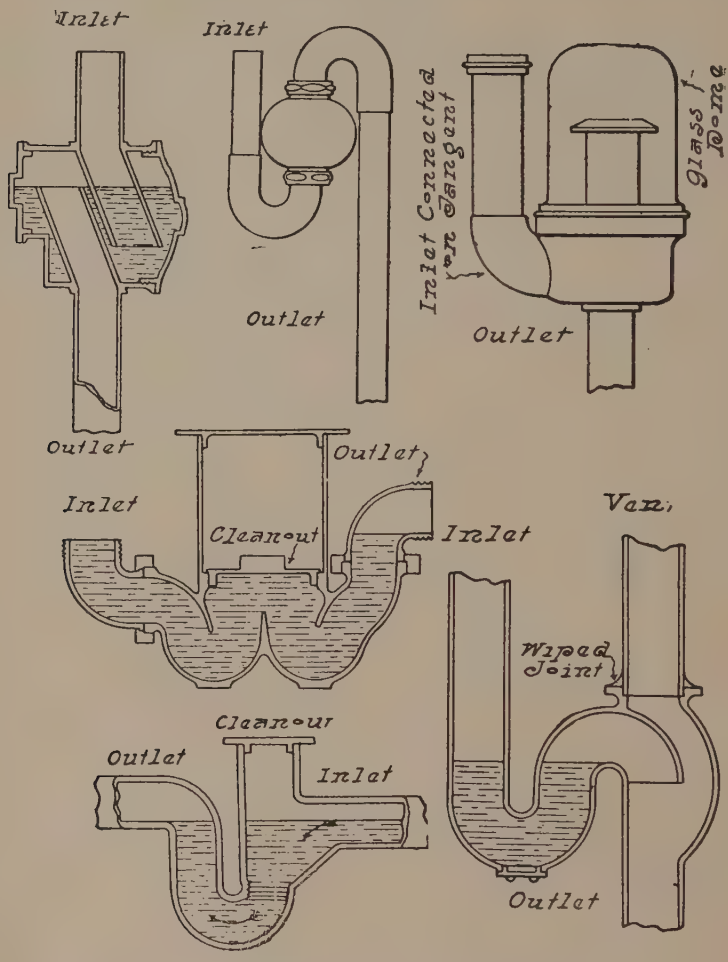


FIG. 30.—Various Patented Forms of Traps.

to that effect, and in procuring from them permission to install his form of trap without venting, a subject which will soon be considered. It is extremely questionable, however, whether the trap has yet been produced which can honestly be said to be entirely

free from the danger of siphonage under all practical working conditions, and after the trap has reached a more or less foul condition incident to its use for a considerable length of time. It is not to be questioned that great strides have been made in the right direction, but it would appear that any trap for use in connection with a plumbing fixture should still be provided with special means to protect it against the action of siphonage. The nearest approach to the desired end is to be found in the modified forms of the drum trap, of which there are many excellent makes.

The results which have been obtained in testing several of the modern traps which are claimed to be nonsiphonable are of much

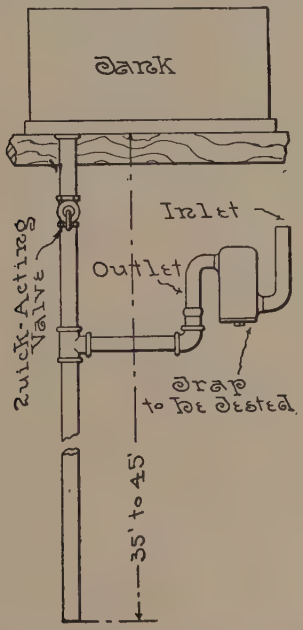


FIG. 31.—The Testing of Traps.

interest, and tend to show how closely some of them are approximating in their operation the result which is desired.

The general method of testing traps is illustrated in Fig. 31. A tank holding about 200 gallons is generally used to provide the flush, and from this tank a $1\frac{1}{2}$-inch pipe is carried down a distance of 35 or 45 feet, the end of the pipe being open, to allow the waste to be emptied upon the ground or to be connected to a drain.

At a point several feet below the tank a branch is taken out, at the end of which the trap to be tested is attached, as shown.

A quick-opening valve having a full water-way should control the flush, by which means the pipe may be quickly and completely filled. The suction created through this length of pipe is great, and puts a most severe test upon the trap, a test much more severe than it is subjected to under ordinary working conditions.

There is no trap, it might be said, which will not lose at least a small part of its seal under an extreme test of this nature.

Traps having a 4- or 5-inch seal have lost in these tests, within the first minute, from 1 to 2 inches of their seal, and often a greater amount. However, in many cases a continuation of the test did not result in further loss of seal.

Many traps under this severe test lose their entire contents, and traps, by the way, which are widely advertised as nonsiphonable.

Those traps having the characteristics of the drum trap, have in general withstood severe tests better than those forms which follow the S type.

It should be noted that traps thus tested are new traps, having no collection of filth in them that is the result of use in actual work, and it is a question whether traps that had been in use for a few years would give such good results under test.

When the nonsiphonable trap becomes an accomplished fact from all practical points of view, there would seem to be no end to the changes that would result in the plumbing system. It will not be a matter of great surprise to see within the next few years, the plumbing system installed without the use of trap vents. When this result comes the decrease in the complex form and in the cost of the plumbing system will be very great. Such a system, however, will not be acceptable until the problems involved shall have been solved beyond a question of doubt.

In considering the perfect trap, especially if of the drum-trap form, an additional danger occurs to us which should be overcome. We refer to the entrance of sewer gas through the trap when the cleanout cover is removed from a trap connected as shown in Fig. 28. This will happen in any trap whose cleanout is not submerged, and it will also happen if the gasket on the cleanout does not make

tight. It is seldom that after the trap is opened the old gasket will make a tight joint, even though it is not destroyed in removing the cover, and it is also seldom that the joint made by a new gasket is tested. Therefore, the perfect trap should be so constructed as to overcome this danger.

The term "trap seal" has been used several times, and it is a matter of importance. Fig. 32 is given as a means of defining it. Under normal conditions, the water in the trap stands at the level A. If, however, it drops below the level B, the trap becomes ineffective, as it no longer prevents the entrance of sewer gas. The

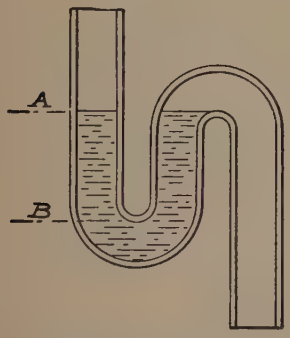


FIG. 32.—The Trap Seal.

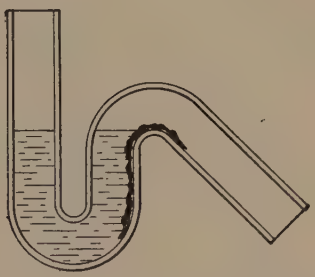


FIG. 33.—Trap Seal Broken by Capillary Action.

water standing between the levels A and B is called the seal of the trap. This seal may be broken or destroyed in a variety of ways. It may be destroyed by siphonage, by capillary attraction, by evaporation, by back pressure, by momentum, and by gusts of wind. Its destruction by siphonage is a matter of such importance that the following chapter will be reserved for its consideration. Defined, capillary attraction is the power possessed by liquids of rising through very fine tubes to a higher level than that of the liquid in which the tubes dip. It is this action which causes a sponge to fill with water. Its application to the breaking of the trap seal may be seen in Fig. 33, which represents string or a collection of lint or other like substances dipping down into the seal of the trap and terminating in the outlet. Capillary action will cause the water in the trap to follow up through this collection of lint and drop over

into the outlet. This constitutes a serious danger to the trap seal, and one for which there would seem to be no remedy. It may readily be seen that in the case of a fixture seldom used, whose trap seal therefore is seldom renewed, capillary action by withdrawing the water from the seal a drop at a time, may eventually destroy it entirely, and the length of time in which such a result might be reached is surprisingly short.

As to the breaking of the seal by evaporation, it may be said that the danger is far less in the unvented trap than in the properly vented trap. This is due to the fact that the vent brings in upon the seal a supply of air which naturally increases the rate of evaporation.

Causes which tend to increase the rate of evaporation are increase of temperature, exposure of surface, and air currents passing over the surface of the liquid.

Back pressure exerted upon the trap seal is a pressure generated in the sewer, and acts upon the sewer side of the trap. A poorly vented sewer may produce such a pressure owing to the expansion caused by a sudden rise in temperature, as might be occasioned by the sudden entrance into the sewer of a large amount of steam or hot water. Tide water backing into the sewer might also produce back pressure. The result of this pressure, unless certain precautions are taken in the construction of the plumbing system, is the saturation of the trap seals with sewer gases, which finally are given off into the interior of the house.

The breaking of the trap seal by momentum is occasioned by the rushing out of the waste from the trap with such force that a part or the whole of the seal is carried with it. This is a danger that exists to some extent in traps working under centrifugal motion.

The breaking of the trap seal by gusts of wind is not a common occurrence, although it sometimes happens. The trap of a water-closet, for instance, located on a top floor, and connected to a soil pipe running through the roof, may lose a few drops of its seal from time to time, owing to gusts of wind passing over the opening of the roof pipe.

CHAPTER VI

THE SIPHONAGE OF TRAPS

As already stated, the trap seal is broken more frequently by siphonage than by any other means. In fact, siphonage is the greatest obstacle that confronts the trap, and it is the one thing that prevents the attainment of the perfect trap.

In order to study siphonic action in connection with the trap, it will be necessary first to consider the action of the simple siphon, and for this purpose Fig. 34 may be used. The purpose to which the siphon is applied is the transferring of liquids from higher to lower levels, and in form it consists essentially of a tube so bent that one arm is longer than the other. The short arm dips into the liquid to be moved, and the long arm delivers the liquid at the lower level. In order that the liquid may be carried over by siphonic action, it is necessary that the air be exhausted in the long arm, or in other words, that a vacuum be created at this point. At the instant that a vacuum is by any means formed in the long arm, atmospheric pressure acting upon the surface of the liquid, no longer having any force counterbalancing it, forces the liquid up the short arm, and over the crown of the siphon into the long, or delivery, arm. Unless broken by other means, siphonic action will continue under these conditions, until the water falls to a point below the bottom of the short arm. When it is considered that atmospheric pressure is approximately 15 lbs. per square inch, it will be seen that with a nearly perfect vacuum, siphonic action is strong and rapid. It is necessary that one arm of the siphon be shorter than the other, in order that the heavier column of liquid in the long arm may exert a pulling force or suction upon the liquid in the short arm. If it were not for this relative difference between the two arms of the siphon, the liquid in each would fall back by virtue of its own weight, and the continuance of siphonic action would be impossible. Therefore, the greater the relative difference

in length between the two arms, the stronger will be the action of the siphon, unless, indeed, the long arm be carried to such a length that friction overcomes the advantage gained.

The action of the siphon may be destroyed by admitting air at or near the crown, a principle which, as will be seen in the following chapter, is made use of in connection with the plumbing system, to prevent the siphonage of traps. While presenting what may be considered as the greatest obstacle which the plumbing system has to overcome, siphonage is also one of the greatest aids in procuring a high grade of plumbing construction, inasmuch as upon the prin-

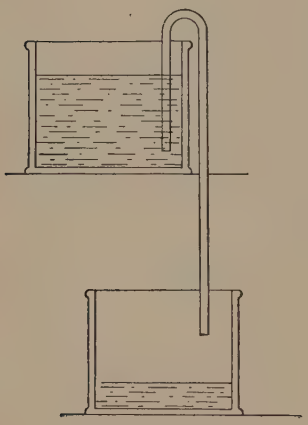


Fig. 34.—The Siphon.

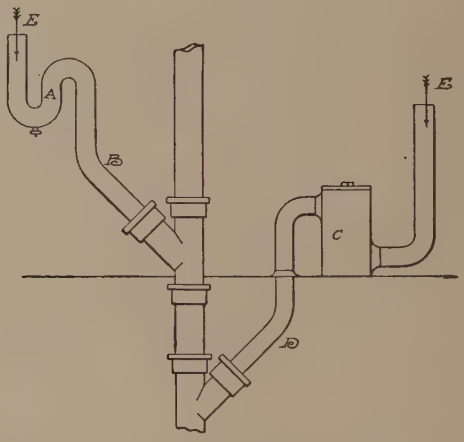


Fig. 35.—The Siphonage of Traps.

ciple of the siphon depends the action of many excellent plumbing fixtures, valves, and other devices. By referring to Fig. 35 it may be seen wherein the connections of both S and drum traps present the same conditions to be noted in the typical siphon shown in Fig. 34. The arm A of the S trap constitutes the short arm of the siphon, and B, the long arm, with the relative difference between the lengths of the two arms often very great. A vertical column of water in the trap of the size of the waste pipe, constitutes in the drum trap the short arm of the siphon, and D the long arm. With atmospheric pressure in each case acting in the direction of the arrow E, all that is necessary to produce the siphonage of the contents of each trap is the formation of a vacuum or partial vacuum in the

long arm. There is usually abundant opportunity in the plumbing system that is unvented, for the formation of this vacuum. In Fig. 35, for instance, it might be formed by the passage of a heavy volume of waste past the entrance of the branches on the two waste fittings on the soil-pipe line. The effect and various causes of siphonage in the plumbing system may best be studied from such an illustration as Fig. 36, which shows a plumbing system such as commonly installed years ago, with no line of soil pipe venting itself through the roof, and without trap ventilation of any description. In such work, the condition most favorable to siphonage is to be found in the fact that the vertical line of soil pipe terminates at the top fixture instead of continuing through the roof with an open end. Suppose now, that a large body of water enters the vertical line of pipe from several fixtures at the same time. Even though the volume is not sufficient to entirely fill the bore of the pipe, owing to its spiral motion in falling, the effect may be nearly equivalent, in which case the air in the pipe is forced ahead of the falling column of water, and a partial vacuum thereby formed in its rear, the effect of which may be felt to a greater or less degree on every trap in the building. By this means each of the traps on the top floor may be siphoned, even the 4-in. water-closet being susceptible to its action. It may readily be seen that in large buildings, where there is a large amount of plumbing of this old-time type, the conditions would often be more severe than those shown in Fig. 36, and the siphonage of traps therefore even more certain. Again, let a heavy body of waste pass down the vertical line of soil pipe from the three floors above the basement. As this column enters the horizontal line, it is naturally retarded; the waste, as a consequence, backs up and fills the pipe at this point, and in attempting to pass out produces a partial vacuum which is certain to be severely felt by the water-closet trap in the basement. It will be noted in Fig. 36 that the waste from the upper bath and lavatory, and from all three fixtures on the second floor has little pitch and is of considerable length. Such conditions are most favorable to trap siphonage, for the lack of fall allows the waste to set back and fill the pipe, and as in the instance noted above, in attempting to pass off, the waste partially exhausts the air in the pipe, and the siphonage or partial

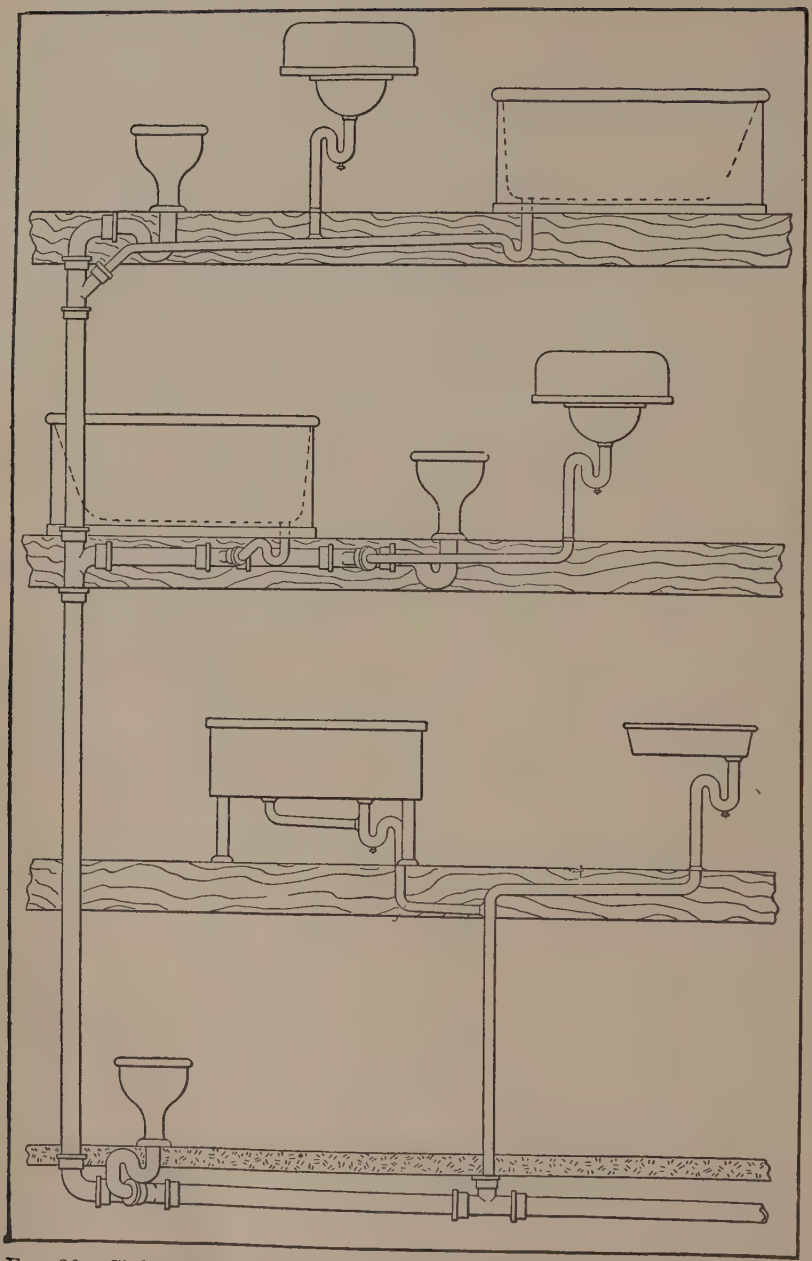


Fig. 36.—Siphonage of Traps in Old-Fashioned Unvented Plumbing System.

siphonage of the traps follows. It should be understood that very often the trap is affected by siphonic action only slightly, possibly only a few drops of the seal being lost at a time. In the event that the fixture is not in constant use, however, it becomes merely a matter of time when enough of the seal will be thus gradually lost to make its destruction complete. Therefore it is plain that even though siphonic influence may not be severe in the case of a certain trap, it still presents great danger.

A stoppage in the waste outlet may have a result similar to that mentioned of fixtures having long wastes without proper pitch. Much old work was put in like that of the kitchen sink and laundry tubs, and here again is abundant opportunity for siphonic troubles. A heavy flow of waste through the horizontal line of soil pipe might siphon either sink or laundry-tub trap; a heavy flow from either fixture might siphon the other; and either fixture might siphon its own trap. Thus it may clearly be seen that the old style plumbing system was susceptible in many different ways to trap siphonage, and the fatal results coming from ignorance of the conditions which actually existed to such a great extent in the plumbing system, and ignorance of the proper remedy for such troubles can hardly be estimated, but must certainly be of great extent.

Fig. 37 shows another unventilated plumbing system, similar in many respects to that of Fig. 36, in which the siphonage of each fixture is a matter of possibility. These illustrations are not exaggerated in any way, but show truthfully the manner in which the unvented plumbing system, with its great and serious defects, was formerly installed.

Fig. 37 shows not only the great possibility of the siphonage of the fixture traps, but shows also other minor defects common to the old-time plumbing system, such as the use of tee fittings on the drainage system, the entrance of waste into the heel of the lead bend, etc.

For the purpose of comparison, Fig. 38 is given, showing a complete modern system of plumbing, with its main line of vents and its branch vents. The great advance which has been made in plumbing installation since the days when such work as that shown in Figs. 36 and 37 was considered sanitary, may easily be seen in comparing the illustrations.

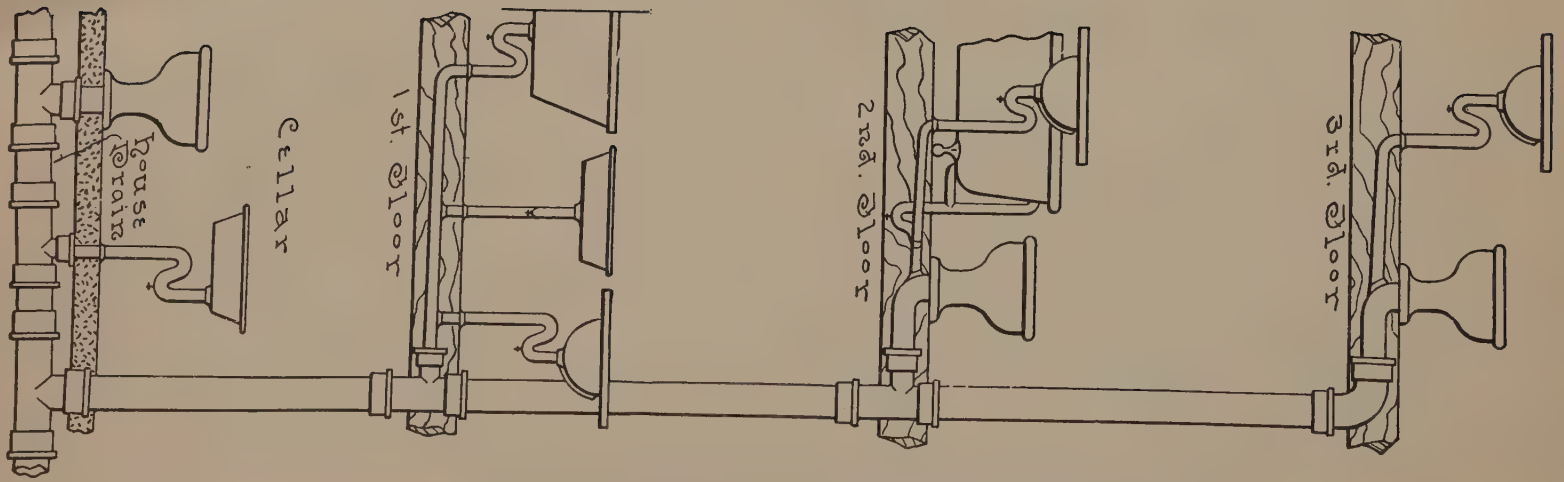


FIG. 37.—Siphonage in Unventilated Plumbing System.

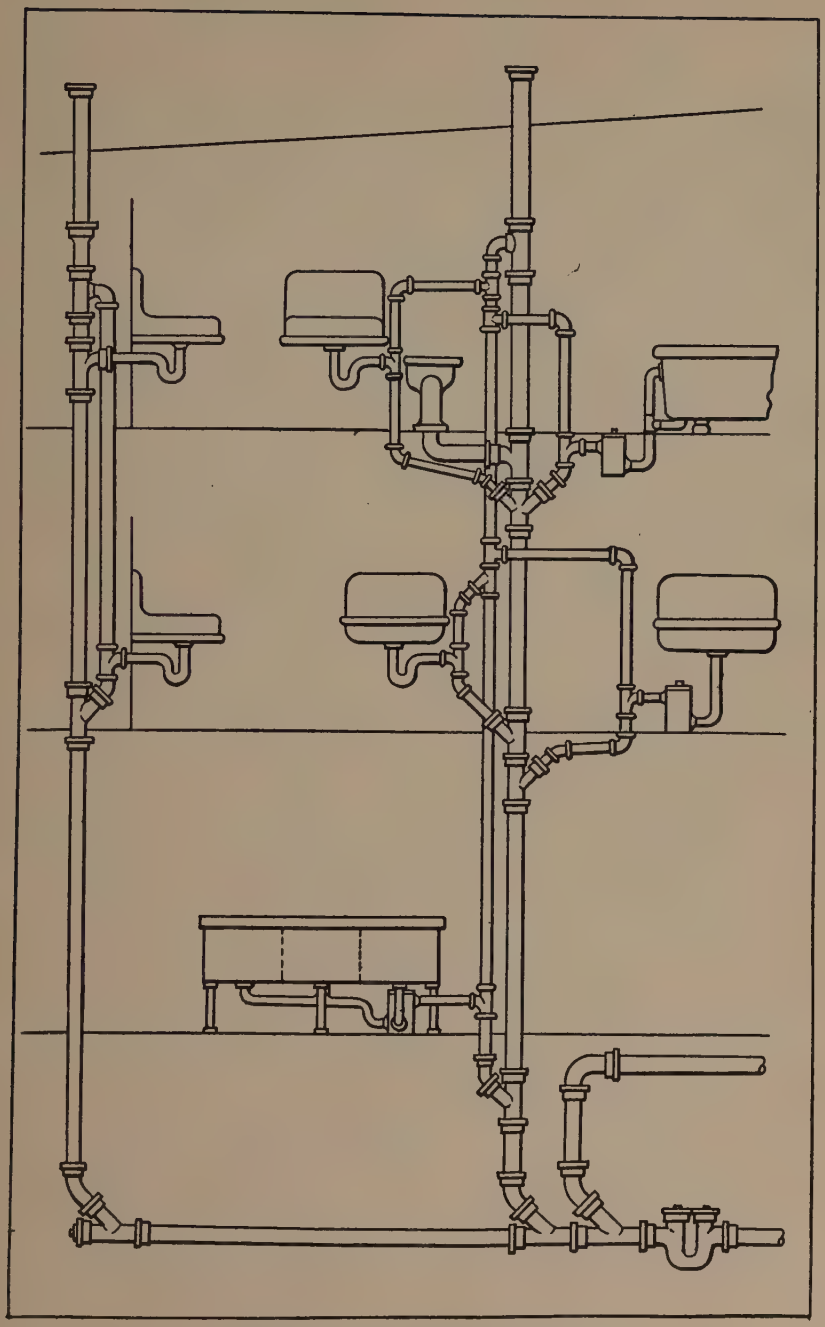


Fig. 38.—The Vented Plumbing System.

The application of the principle of trap venting has, without doubt, been the chief cause of such vastly improved sanitary conditions in the plumbing system. It is the venting of fixture traps which has proved the only practical means of preventing trap siphonage, and this subject in theory and in its practical application will be taken up in a special chapter on the subject of venting.

CHAPTER VII

VENTING

While as a principle it has been known for ages, it is only within a comparatively few years that venting has been applied to the plumbing system as a means of overcoming such troubles as those mentioned in the preceding chapter. As a matter of fact, however, venting to-day stands second only in importance to the trap in a properly installed plumbing system.

Venting may properly be considered under two heads, soil or waste vents and trap vents. There are also two other forms of vent, the local vent and the fresh-air inlet, neither of which apply to our present subject, but which will be considered in later chapters. By the soil or waste vent is meant the continuation of vertical soil or waste-pipe lines above the highest fixtures and through the roof, terminating with an open end. It will readily be seen that the use of this vent prevents all trouble from back pressure in connection with trap seals, the vent relieving all pressure that might be generated in the sewer. The importance of this vent is realized when the plumbing system shown in Fig. 36 is compared with the same system supplied with the soil and waste vent. Not only does this vent relieve the system of back pressure, but it also purifies it, and lengthens its life, and in addition is often an aid in installing the trap vents, as will soon be seen. The soil and waste vent should ordinarily be carried at least two feet above the roof, and always above any opening on the roof, or the windows of neighboring buildings. There is one source of danger to this vent that should always receive attention, particularly in cold climates. Steam from the plumbing system will in cold weather form a mass of frost about the vent opening, and in the case of the smaller sizes of soil pipe often close the opening entirely. All sizes smaller than 4 inches may be closed in this way. Therefore no pipe of less size than 4 inches should pass through the roof, all pipes of

smaller size being increased to 4 inches below this point, as in Fig. 59. Some plumbing ordinances require an enlargement of only one size in diameter. This would mean that a 2-inch pipe need be increased only to 3 inches in passing through the roof. The first-named provision, however, we believe to be the better. Vent covers are frequently fitted to the tops of roof pipes, which is certainly wrong in principle. It is better practice to discard even the wire cage which is so commonly used, for even this contracts the opening and allows the frost to accumulate more readily than it would in the open end of the pipe. Trap venting is the subject next to be

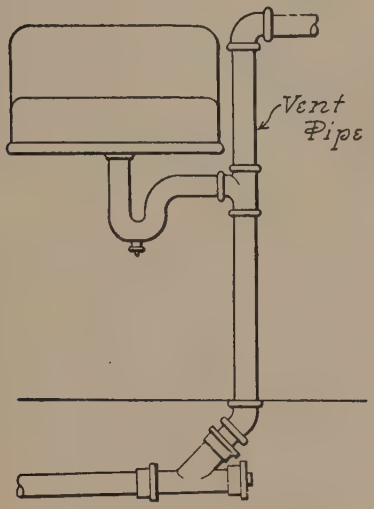


Fig. 39.—The Vented S-Trap.

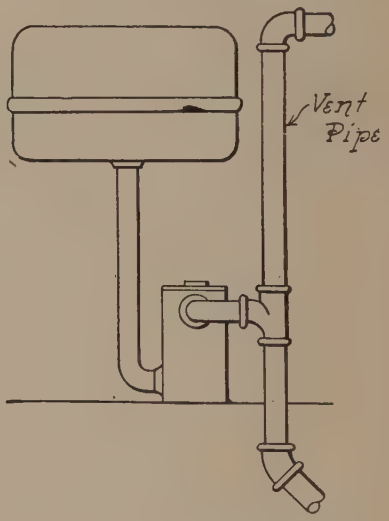


Fig. 40.—The Vented Drum Trap.

considered, a subject both important and extensive. It has been seen in the preceding chapter that the admission of air to the crown of the siphon will destroy its action. It must necessarily be destroyed, for the admission of air destroys the vacuum upon which siphonic action depends. Briefly stated, then, the trap vent used on the plumbing system is a pipe, as shown in Figs. 39 and 40, whose purpose is to carry a supply of air to the crown of the trap, thereby preventing the formation of a vacuum in the outlet from the trap, and making the siphonage of the contents of the trap an impossibility. In order to perform its work, the trap vent must be

connected with the outside atmosphere. This is accomplished by connecting the trap vents of the several fixtures into a main vent, the latter either passing through the roof to the outer air, or connecting into the soil and waste vent above the highest fixture. The trap vent, or back vent, as it is also called, should be connected to the trap at or near the crown, and on the sewer side of the trap. The connection of this vent to the trap and into the main vent may be seen in Fig. 41. The vent should always enter the main line of vent at a point higher than the fixture itself. If connected below

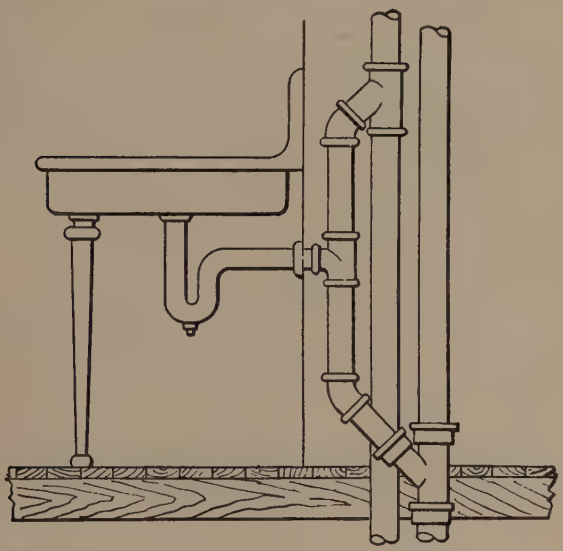
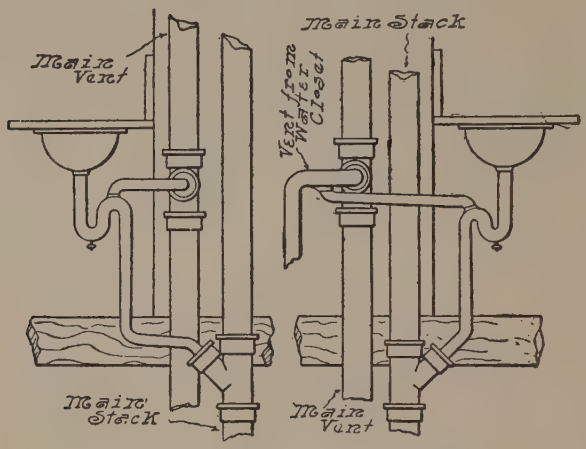


Fig. 41.—The Trap Vent.

the fixture it may easily be seen that in the event of the stoppage of the outlet from the trap, the waste would pass out through the vent into the drainage system and thus continue until the vent in turn was stopped. This condition occurs in the work illustrated in Figs. 42 and 43, the former representing the trap vent connected directly into the main vent, and in the latter the trap vent connected into a vent from another fixture.

When properly connected, waste in the case of a stoppage would be unable to pass over through the vent, and would set back into the fixture, thus giving warning of the existence of trouble.

While in principle the proper point for the connection of the vent is at the crown of the trap, there is an objection to this course from the fact that it brings in the supply of air directly upon the



FIGS. 42, 43.—Wrong Connection of Vent.

seal of the trap, thereby greatly increasing the rate of evaporation. It is better, therefore, to connect the vent in such a way that this danger may be obviated as far as possible. Fig. 44 shows how this may be done in connection with the several styles of S traps. From

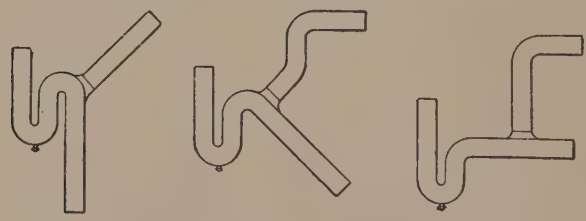


FIG. 44.—The Stoppage of Vent Openings by Grease, etc.

the nature of its connections, precautions of this kind are not so essential to the drum trap.

In the connection of the vent to the trap, a very important point is the making of the connection in such a way that the possibility of the stoppage of the vent opening by grease, lint, etc., in the waste may be made as slight as possible. In Fig. 44 the danger of such

stoppage is present in the case of each of the three traps, but least of all in the half-S trap, and it may be added, also, that in this trap the rate of evaporation will also be less than in the others, owing to the distance of the vent connection from the seal. The stoppage of the vent opening is in reality the greatest obstacle that the vent system has to contend with.

It is a fact that after being in use for a length of time, a large majority of vents connected as in Fig. 44, become almost, if not entirely closed with grease, lint, etc., and in that condition of course become inoperative. Many expedients have been tried in the manufacture of traps to overcome this difficulty, but with little apparent success. Some few plumbing ordinances call for the location of a cleanout on each trap vent, but this is by no means a solution of the difficulty, for the seat of the trouble is always hidden from view, and that a stoppage of the vent exists is almost never known. In addition, the average owner or tenant knows so little concerning these matters that he cannot be depended upon to clear the vent at proper intervals, and in most cases not at all. The knowledge of the great extent of this evil is one of the chief reasons for the great activity in the search for a nonsiphonable trap, such a device naturally not requiring the vent, and therefore being free from this trouble.

Certain cities have even gone so far as to adopt the nonsiphonable traps now on the market, allowing their installation without venting, preferring to take chances with the so-called nonsiphonable trap rather than with the ordinary trap and its attendant closed vent. The modern form of venting, known as continuous venting, as distinguished from old-style crown-venting, is free from the stoppage evil, and the subject is of such importance that the following chapter will be devoted to its consideration. A stoppage of the trap vent is to be considered more dangerous than a stoppage of the waste, as the latter quickly makes itself known by the setting back of the waste into the fixture, while the former is seldom known unless the work is taken apart.

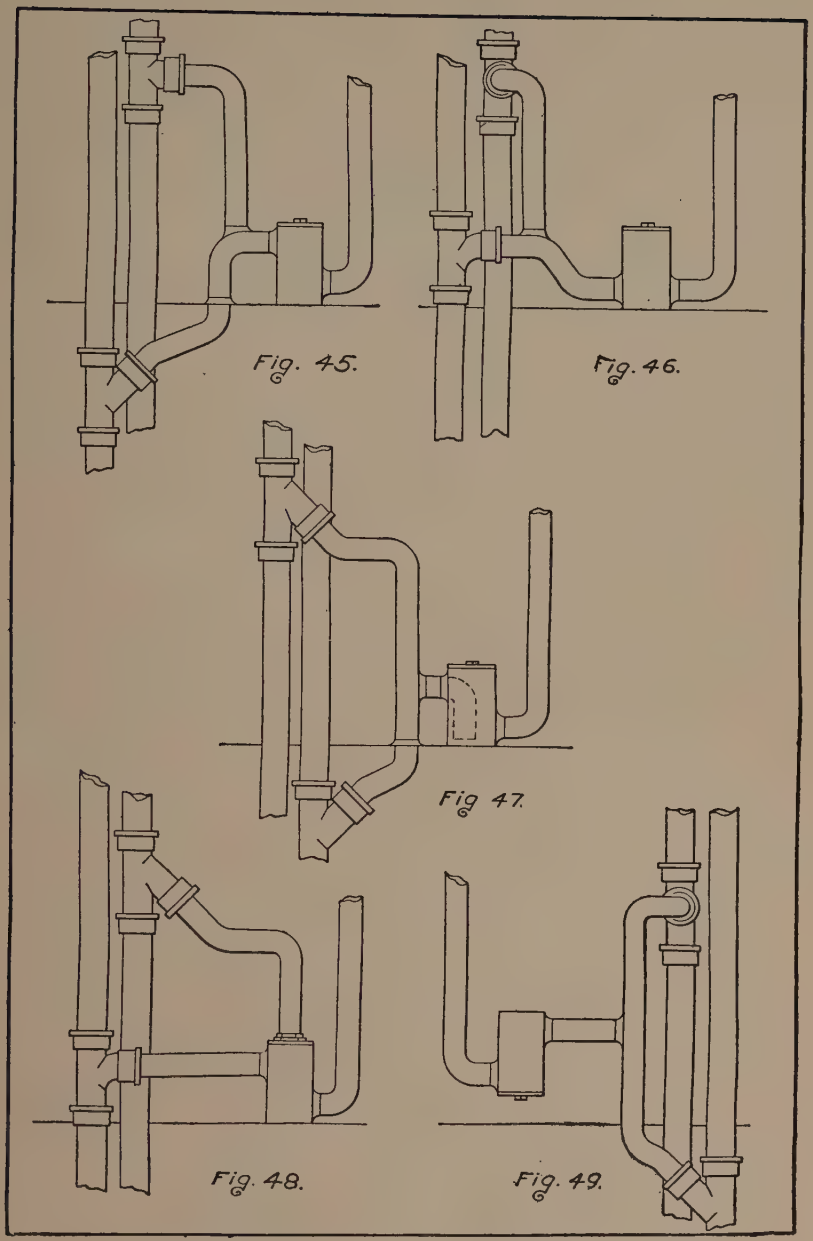
Little has thus far been said concerning the vent and waste connections of drum traps, and a consideration of the subject will be of value. Until continuous venting came into common use, probably a large majority of drum traps were installed with vent

connections much like those of Fig. 45. Other more or less common crown-vent connections are shown in Figs. 46 to 49. The chief argument against the Fig. 45 connections is that if the trap screw gasket is not tight, there will be direct communication between the drainage system or the sewer and the interior of the house. This trouble may be avoided by a connection such as in Fig. 46. The objection to the latter however, is the fact that there is of necessity a greater length of pipe in which waste may stand and foul the outlet pipe. The connections of Fig. 47 also prevent the escape of gases when the trap screw is off or not tight, but there is an objectionable feature in allowing the outlet pipe to project into the trap, in that it presents an obstruction in the body of the trap, and around it filth may collect, making the stoppage of the trap more probable. This vent connection, however, is more free of the danger of stoppage than most of the other connections shown. This fact applies also to Fig. 49.

The method of taking the vent connection off the trap-screw cover, as shown in Fig. 48, has been quite a common one in the past, but is not to be recommended, as each time the trap has to be cleaned, it is necessary to twist the vent pipe back out of the way. The connections shown in Fig. 49 are in many respects very good.

While some of these crown-vent connections show superiority over others, not one of them is free from the possibility of stoppage of the vent opening, and for this reason the continuous vent connections for drum traps, as shown in Fig. 41, are to be considered far superior.

In providing a supply of air to the trap vent, one of three courses may be followed. If there are no fixtures above, it may be entered into the soil or waste vent at any point below the roof; it may be carried directly through the roof; or it may be carried into a line of main vent, as shown in Figs. 45 to 49. The only objection to entering the trap vent directly into the soil or waste vent when there are no fixtures above, is that unless the fixture is on the top floor, other fixtures may be located above at some future time. The carrying of the trap vent directly through the roof not only makes an extra roof connection necessary, with considerable extra expense, but as such a pipe is somewhat apart from



Figs. 45–49.—Waste and Vent Connections of Drum Traps.

the main system, the air in it is colder and the circulation of air therefore less satisfactory. The most approved method, then, is to connect the trap vent into a main line of vent, illustrations of which will be seen later. A very important point in the running of trap vents as well as main vents, is that they shall pitch upward at every point. A considerable amount of condensation and scale forms in the vent pipes, and if there is no pitch on the pipes these accumulations cannot find their way back into the trap, where they may flow out through the waste. The size of the trap vent should generally be the same as that of the trap to which it is connected.

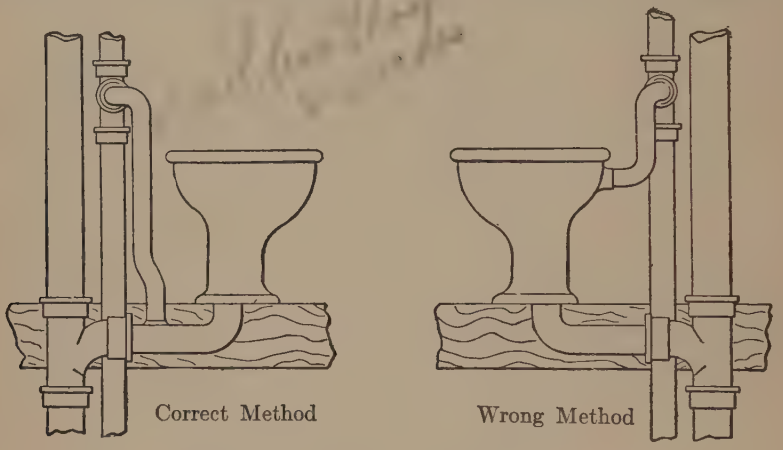


FIG. 50.—Venting of Water-Closets.

The important exception to this rule is the vent from the water-closet. The waste from the water-closet is 4 inches in diameter, but experience shows that a 2-inch vent is sufficiently large.

Fig. 50 shows the correct and the wrong method of venting the water-closet. When properly installed, a 2-inch vent is taken from the top of the horizontal part of the lead bend, carried above the fixture and entered into the main vent. It is considered poor practice to connect this vent on the vertical arm of the bend, as paper and other substances are liable to collect about the entrance and finally close it. Its location on the horizontal arm of the bend is comparatively free from this difficulty. Another very good method, the principle of which is similar, is the connection of the vent to the vent hub of a vented T-Y fitting, into which the lead

bend is calked. This method will be illustrated later. The incorrect method, shown in Fig. 50, consists of the connection of the vent to the vent horn of the water-closet, a method which is now prohibited by nearly all plumbing ordinances. The objection to such a method is that any blow which the fixture may receive, or the settling of floors, will break off the vent horn, for the reason that the vent pipe is usually too rigid to take up any movement of the closet. The water-closet is naturally the fixture most difficult to siphon, inasmuch as it is more difficult to form a vacuum in a 4-inch pipe than in pipes of smaller diameter. Therefore, it is not

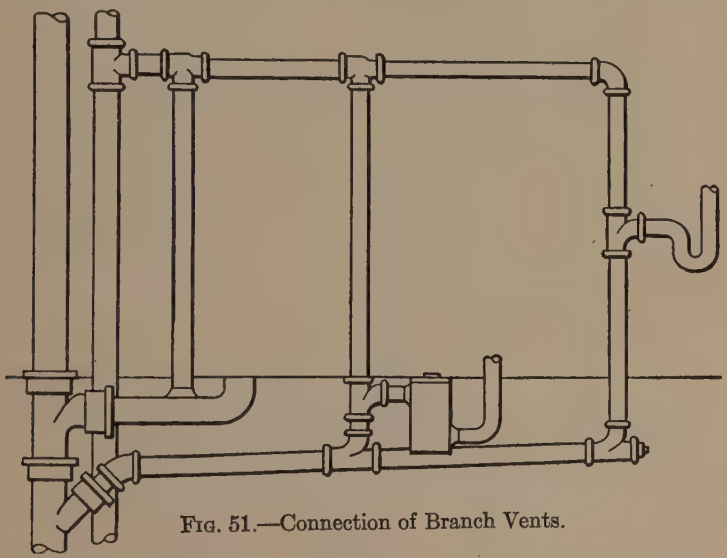


Fig. 51.—Connection of Branch Vents.

necessary to vent this fixture under certain circumstances, for instance, when it is located close to the stack on the top floor. In this location, with no fixtures above it to produce siphonic conditions, there is nothing to be gained in venting. The vents from a number of fixtures may be connected into one line, and this line connected into the main vent, such a method often being more advisable for many reasons than the running of each trap vent separately into the main. When so installed, however, as the several vents enter the branch to the main vent, the size of the branch vent should be increased, as shown in Fig. 51. In the case of a small number of fixtures, however, such as to be found in the bath room,

the 2-inch vent to the water-closet need not be increased in size after receiving the vents of the other fixtures, as it is of sufficient size to provide air to the several fixtures.

In order to make sure that no vent shall act as a soil or waste pipe in the event of stoppage of any part of the waste the main branch vent should enter the vertical main line of vent above the top of the highest of the fixtures. Very often a fixture is located at a considerable distance from the main vent to which its trap vent is to be connected. When this distance is 8 feet or more, the trap vent should either be carried independently through the roof or

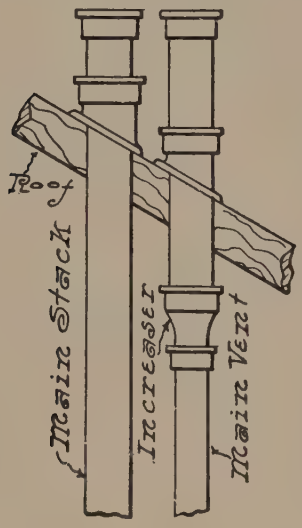


FIG. 52.—Main Vent and Main Stack Separately through Roof.

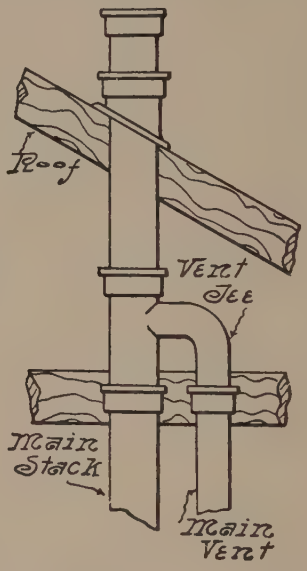


FIG. 53.—Upper Connection of Main Vent into Main Stack.

enter its main vent at a point above all fixtures. Another necessary provision is the increase in size of pipe used on long lines of vent. After passing 30 feet in length, the size of the vent should be increased one size. This precaution is necessary from the fact that in long lines of pipe, friction will decrease the efficiency of a pipe in delivering an adequate supply of air to the trap. In the running of main vent lines, many of the principles that apply to the trap vent are to be followed. There are, however, several points

which should be considered that do not enter into the subject of the trap vent. In order to perform their work, the trap vents must be provided with a supply of air, and therefore the main vent must open into the outside air. One method of doing this is to run the

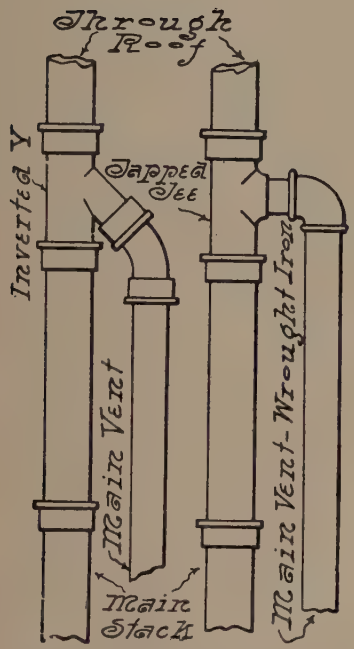


Fig. 54.—Two Methods of Upper Connection of Main Vent into Main Stack.

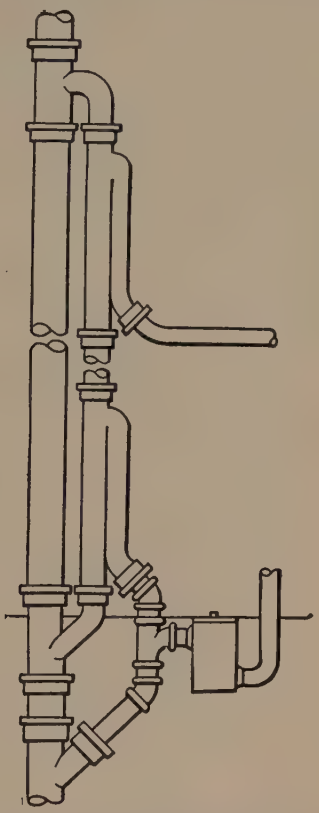


Fig. 55.—Top and Bottom Vent Connections and Special Vent Fittings.

main vent directly through the roof, as in Fig. 52. The ordinary method, however, is to connect the main vent into the main stack above all fixtures, as shown in Figs. 53, 54 and 55. Below the lowest waste connection into the stack, the main vent should be connected back into the stack, as in Fig. 57. This connection is made in order that all scale and condensation forming in the pipes may escape into the drainage system, to be washed away. Fig. 58 shows the use of a special fitting for making this connection, which

allows the two vertical lines to be run very close together. In Fig. 59, at B, is shown a wrong method of connecting the main vent into a trap vent, instead of re-entering the main stack. The same connection may perhaps be seen more clearly in Fig. 56.

When the lower end of the main vent stack is reduced to receive a trap vent, as in Fig. 56, there is abundant opportunity for the collection of scale, rust, and condensation in the heel of the reducing elbow, and no opportunity whatever for it to be washed

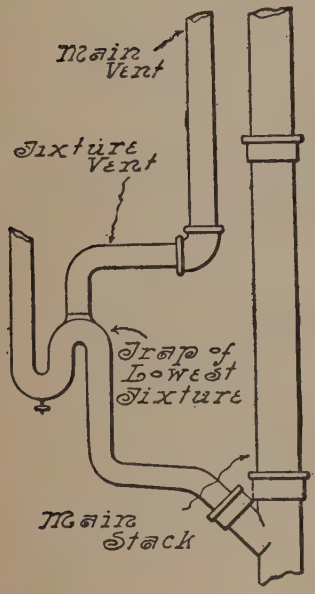


Fig. 56.—Wrong Method of Lower Connection of Main Vent.

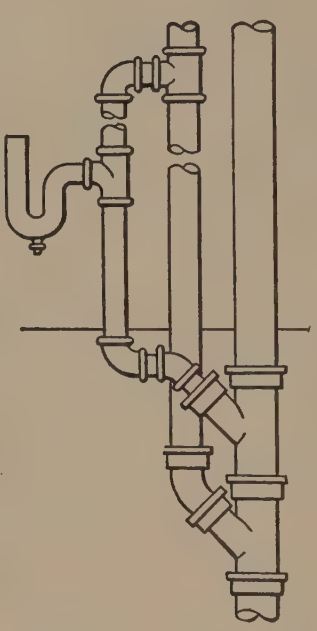


Fig. 57.—Improved Lower Connection of Main Vent into Main Stack.

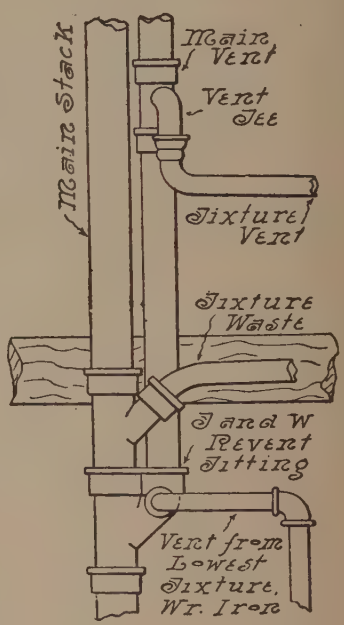


Fig. 58.—Special Main Vent Connection.

away as in the correct method. The latter connection is the more rigid of the two also. For these reasons the connection of Fig. 57 is the one now generally called for by the best plumbing ordinances.

Fig. 59 shows the various connections on the vent system, with various common fittings in use.

In Fig. 55 also are shown main vent connections, and a special

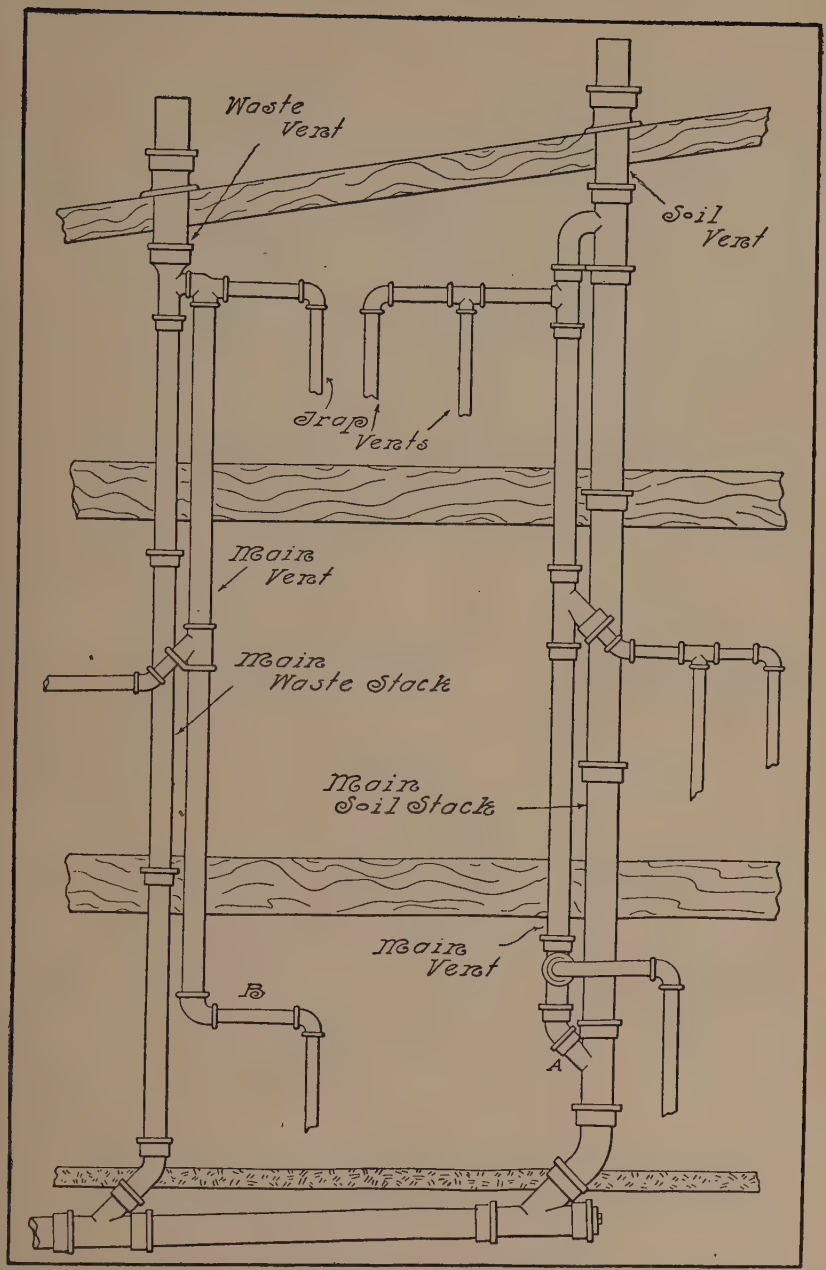


FIG. 59.—Vent System, Showing Main and Trap Vents, Use of Fittings, etc.

form of vent fitting, which is not only excellent in principle, but allows the work to be installed very compactly.

A few words should be said concerning the material used on the vent system. For main vent lines cast iron or galvanized wrought iron pipe is used, and for trap vents either brass, lead, or galvanized wrought iron, the latter being the most extensively used in both cases.

CHAPTER VIII

CONTINUOUS VENTING

As seen in the preceding chapter, the great obstacle to the operation of the trap vent is the collection of grease, etc., about the vent opening into the trap, in such quantity as to completely close the opening. If the vent should be disconnected from the trap it would be found that in a vast number of cases the opening is completely closed, and the vent entirely useless, which condition generally renders the trap easily subject to siphonage. As already stated, numerous mechanical devices have been tried in the attempt

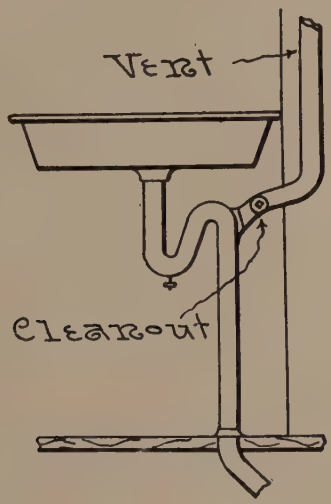


FIG. 60.—Cleanout on Trap Vent.

to regulate this difficulty, but all without avail. Even the use of the cleanout on the trap vent, as seen in Fig. 60, does not constitute a solution of the difficulty, although in some cities it is required. The trouble seems to be too deep-seated to be remedied by superficial means. In order to solve the difficulty, a different principle

should be applied, and it would seem that in the continuous vent a very satisfactory solution has been found. There may be places where it is difficult to apply this method, but in general it may be successfully done.

In Fig. 61 are shown two examples of the application of the continuous vent to both the S and the drum trap.

This vent system is, by the way, sometimes called "venting in the rough." The principle involved in the continuous vent is readily seen. It consists essentially in the use of a fitting of the

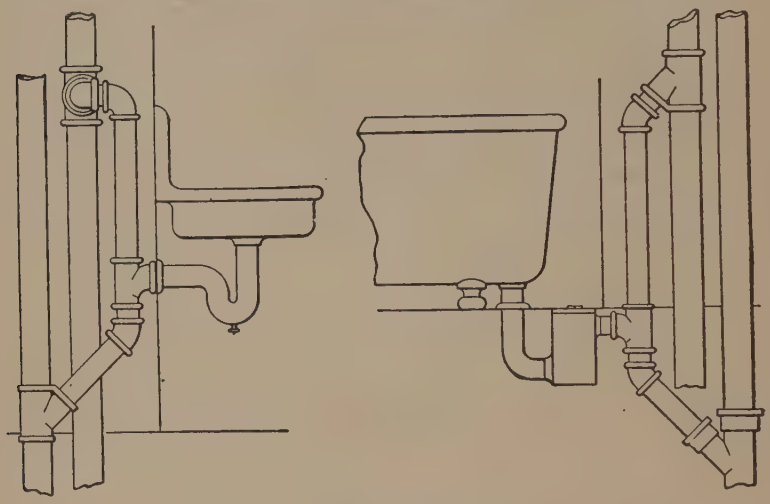


Fig. 61.—The Continuous Vent.

T-Y style, in such a manner that the vent may be taken from the top of it, and the waste from the bottom. This form of installation necessitates the use of the half-S trap, and prohibits the use of other forms of S trap, with the exception of the running S trap. It hardly need be stated that the opportunity of closing the vent opening is far less in this form of venting than in the method of the preceding chapter, which is in common use. This opening is not only further from the trap, and therefore more free from the splashing of the waste as it enters the trap, but the use of the T-Y fitting also tends to make the accumulation of grease about the opening more difficult. Another advantage gained in the use of the continuous vent is that no part of the work need be exposed to

view, with the exception of the trap itself. This, as may well be supposed, is often a valuable feature. Generally when this style of vent is used, the material employed on both waste and vent is either brass or galvanized wrought iron, although lead may be used if for any reason it is found to be more desirable.

In a great deal of work on which the continuous vent is used, the cost of stock and labor involved is very much less than when the same work is installed according to the methods shown in the preceding chapter. This is particularly true of certain classes of large work. Fig. 62, for instance, shows the continuous vent prin-

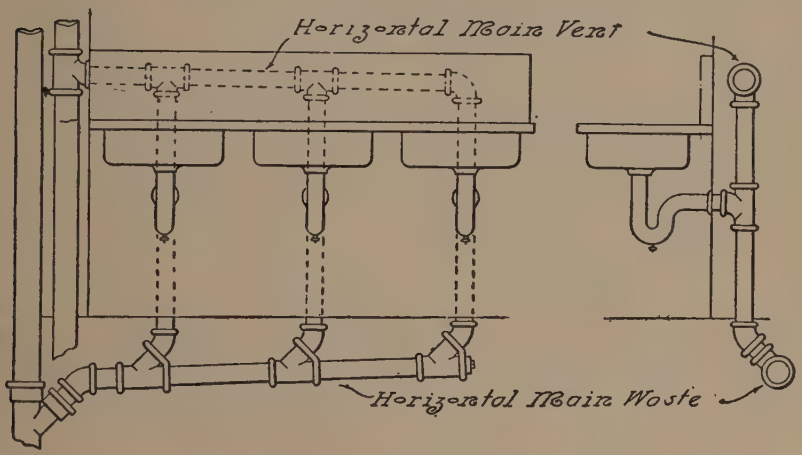
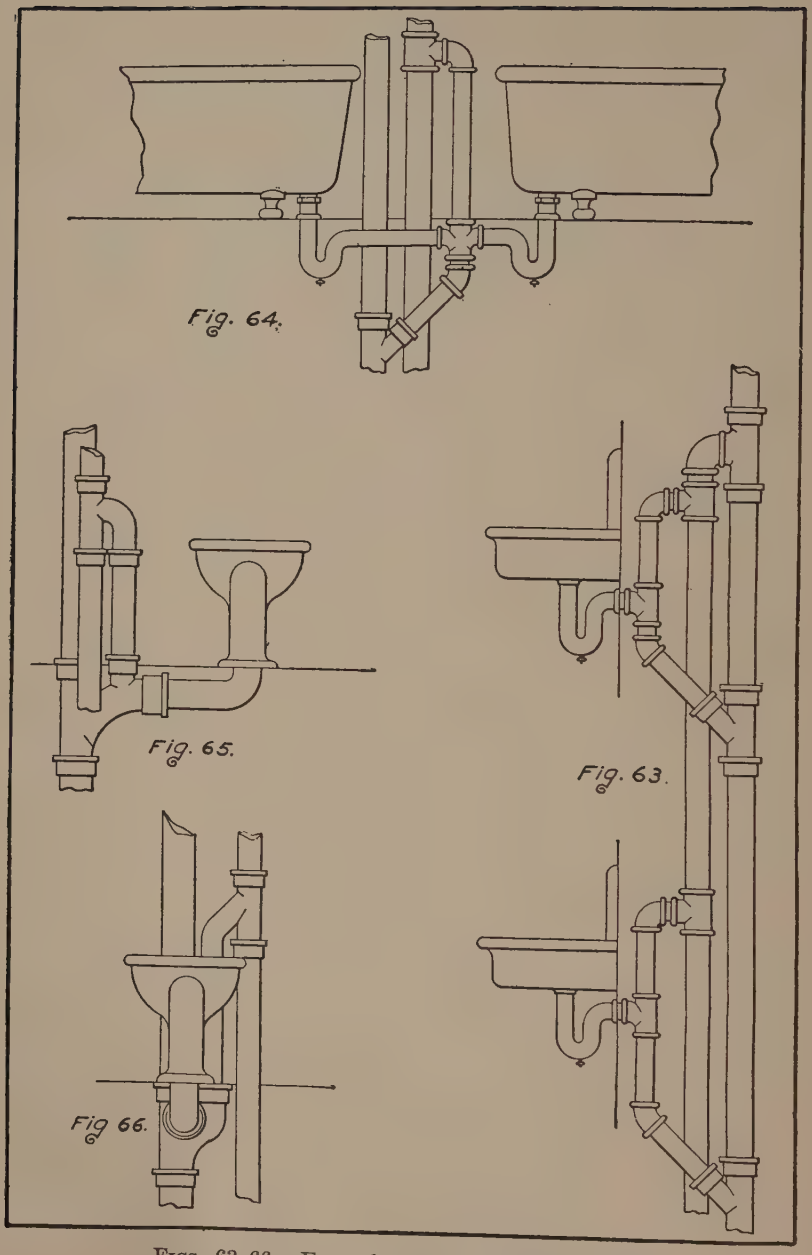


FIG. 62.—Continuous Venting for Line of Fixtures.

ciple applied to a line of fixtures, both front and end views being given. To this type of work the principle is particularly adaptable, and is being constantly employed to a greater extent. The method allows both horizontal main waste and main vent to be run back of partitions, concealed from view. Another material advantage of the continuous vent is the fact that the vent is taken off so far from the trap that the rate of evaporation is far less than under the conditions existing in work as ordinarily constructed. This is a more important feature than is generally acknowledged, for many traps, otherwise properly installed, fail because of the evil due to evaporation. In Fig. 63 is shown a vertical line of fixtures entering a waste stack, the traps being provided with con-



FIGS. 63–66.—Examples of Continuous Venting.

tinuous vents, and in Fig. 64 the same style of work in connection with a double line of fixtures on opposite sides of a partition. Double lines of fixtures are very often to be found on large work, such as apartment and office buildings, hotels, schools, factories, etc., and on such work as this there is no question whatever that the saving in labor and material is very great.

In Fig. 65 is shown a water-closet vented from the vent hub of a vented T-Y, a method which is very acceptable. This particular vent is not generally spoken of as a continuous vent, but it actually is in principle, and is therefore considered in this chapter. Such

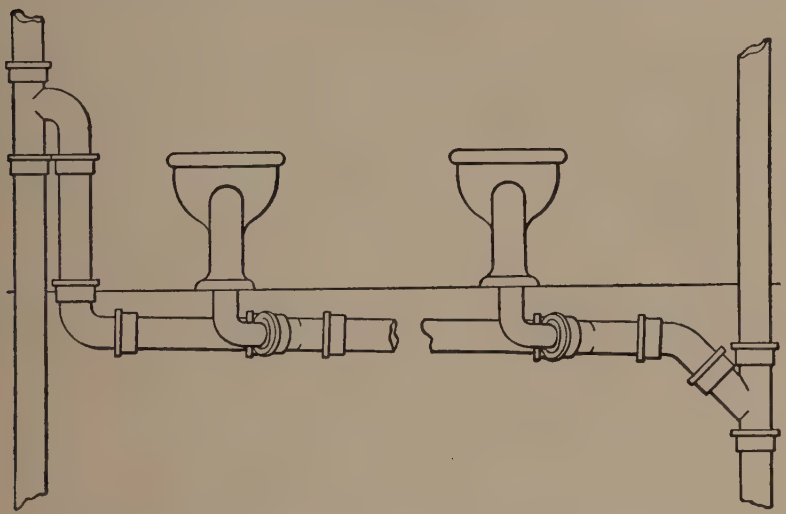


Fig. 67.—Continuous or Circuit Venting of Water-Closets.

work is very substantial, and particularly adapted to locations in which the plumbing is liable to rough usage, as, for instance, in factory work.

Fig. 66 shows the use of special patented fittings designed for vent work, the principle being very similar to that involved in the work of Fig. 65. In this connection it may be said that a great variety of vent fittings are now made, many of which will be noted in later illustrations, which are of very great value in the construction of continuous venting. Another modified form of continuous vent is to be seen in Fig. 67. This style of work, known as circuit venting, is applicable only to batteries of water-closets,

but as it often happens that in the plumbing of hotels and other public buildings, extensive toilet rooms are located one above the other, the occasion often arises where the principle referred to may be put to good use. The illustration shows a line of water-closets on one floor only, but similar work on floors above or below would be put in in a like manner. The idea consists in the location at either end of the line of water-closets, of a vertical stack, one for soil and waste, and the other as a main vent. Each vertical line is carried through the roof, thus affording abundant circulation of air for each line of fixtures. Here again a great saving is made in labor and material over the separate vent method, in which a vent is taken from each lead bend. In the case of such work as that of Fig. 67, if fixtures other than water-closets waste into the horizontal soil pipe serving the water-closets, the vents from such fixtures may be run in the ordinary manner and connected into the vent stack.

It may be said that the continuous vent will prove a most valuable feature in the attainment of a perfect plumbing system, and that when its value becomes more thoroughly understood and appreciated, it is bound to be universally adopted. Indeed, it appears strange that it is not already put to more extensive use, as it certainly is a solution of some very serious problems.

CHAPTER IX

HOUSE SEWER AND SEWER CONNECTIONS

Having now considered the two fundamental subjects of traps and venting, the entire plumbing system will be considered, beginning at the point where the house sewer connects into the public sewer. Before proceeding with the subject, it will be well to define several terms, which are not always clearly understood.

By house drain is meant that portion of the horizontal drainage system into which all soil, waste, and drainage pipes discharge within the walls of the building which the drainage system serves. The house drain conveys the drainage to a point outside the foundation walls into the house sewer.

By house sewer, lateral or main drain, is meant that portion of the horizontal drainage system which extends from the house drain outside the foundation walls into the public sewer.

By house connection is meant that part of the house sewer which lies between the public sewer and the curb line.

By crock drain or sewer is meant any drain or sewer constructed of vitrified earthenware, hub and spigot pipe.

By tile drain is meant any drain constructed of hard-baked earthenware pipe, which is laid with open joints, and having no hub and spigot ends. Tile drain is a name often wrongly applied to the crock drain.

The house drain usually ends at a point 10 feet outside the foundation walls, and at this point enters the house sewer, which is generally constructed of vitrified earthenware pipe, although occasionally the cast-iron pipe of the house drain is continued to the public sewer.

No earthenware pipe should be allowed inside the foundation walls of any building, on any part of the drainage system. All plumbing ordinances now make this prohibition. The reason for this is that owing to their nature, the cement joints used on this

style of pipe are liable to break or crack, or the pipe itself to suffer like injury, in which event the sewage will leak out and produce conditions unsanitary in the extreme. Breaking of pipe and joints may often occur from various causes, such as settling of the ground, etc.

The house connection is a term not so definitely defined as might appear from the definition above.

In some cities the house connection continues only to the curb line, in others to the fence line, and occasionally to the house sewer at the foundation wall. In each case this part of the drainage system is usually under the care of the municipal authorities, and the plumber allowed to work on it only under certain conditions and restrictions. In many cities a regularly appointed sewer inspector inspects all work done on the house connection, and only those plumbers may perform this class of work who have the proper license and permit from the proper officials.

This chapter will have to do principally with the house sewer.

This part of the drainage system, as before stated, is generally of vitrified earthen pipe. Much care should be exercised in making the connection between the house sewer and the public sewer, as a serious fault at this point renders an otherwise perfect drainage system useless.

Fig. 68 will serve to show some of the points of importance that should be observed. In the first place the branch for the house sewer should enter the street sewer above the center at a point high enough to guard against the setting back of the contents of the street sewer into the house sewer at such time as the former is carrying its maximum amount of sewage. It can readily be seen that in the backing up of sewage into the house sewer there is danger of the latter being closed up with heavy matter from the street sewer.

In addition, a Y branch, pointing in the direction of flow in the street sewer, is preferable to a tee, inasmuch as there is less liability of the collecting of such materials as rags, paper, etc., about the entrance.

An eighth bend into the Y will bring the course of the house sewer at right angles to the street sewer. Sharp, abrupt bends should never be used on this part or in fact on any part of the

drainage system. If necessary to make a turn of 90 degrees, it should be done by means of eighth or sixteenth bends rather than by the use of a quarter bend. Precautions should be taken that the Y branch, or any cement used in making the joint, may not project inside the street sewer and thus present projections upon which matter floating in the sewage may catch. The

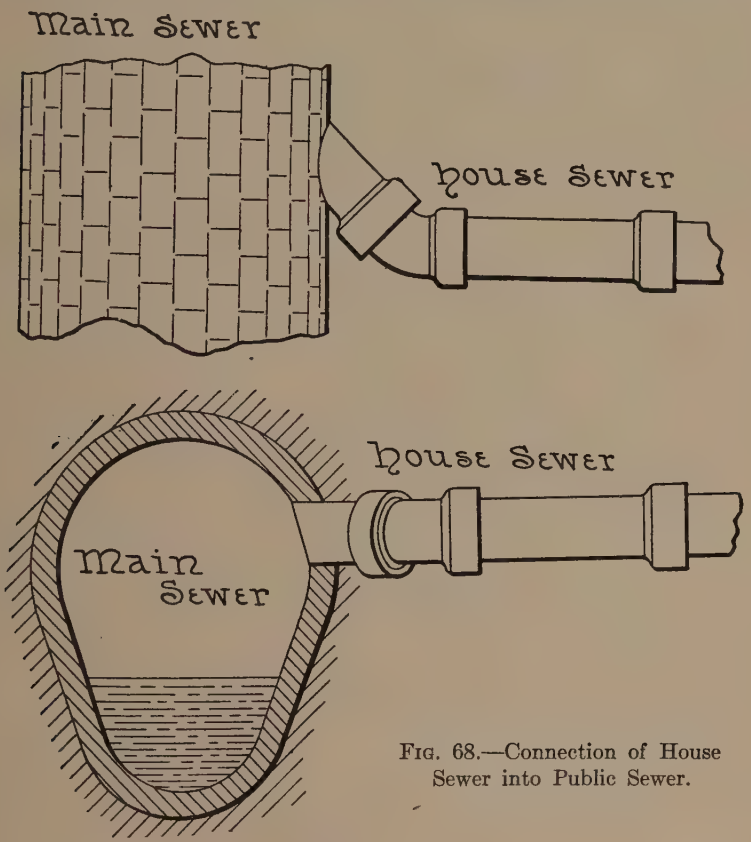


FIG. 68.—Connection of House Sewer into Public Sewer.

house sewer should be laid on a grade of not less than 1 foot in 100 feet, and more pitch is desirable when possible to secure it. The trench in which the house sewer or any other underground drain is laid, should have a uniform slope and on the bottom depressions should be made to receive the hubs of the pipe. Each length of pipe should be given a solid bearing throughout its length. The best foundation for the laying of the house sewer is

a natural bed of earth, gravel, rock, or sand. If such a foundation is not attainable, concrete may be laid beneath the pipe as a support. Chestnut planking also makes a good foundation on which to lay the pipe. Whenever the ground is made, or filled in, or where there is possibility of the settling of the pipe, or danger from the roots of trees, from frost, etc., it is preferable to construct the house sewer of extra heavy cast-iron pipe. The earth about the pipe should always be well rammed.

Special care should be taken in the making of joints on this part of the work. In general this work is done by unskilled workmen, and the attention is not given to it that its importance should demand.

If the joints are unglazed they should first be wet, and the space between hub and spigot completely filled with Portland cement. This cement should be made of one part Portland cement and three parts of clean sand. In the use of pipe having glazed hub and spigot ends the hub should first be calked half full with oakum, and the remaining space filled with Portland cement. This method should also be followed in making the joint between the cast-iron house drain and the earthenware house sewer.

In the case of the last-named joint, if the house sewer is more than one size larger in diameter than the drain, an increaser or reducer should be used in making the connection.

After each cement joint is made and before starting on the next one, all mortar projecting from the inside of the joints should be cleaned off by the use of a swab.

The danger of leaving superfluous cement projecting into the drain may be seen from Fig. 69. Such projections present sharp,

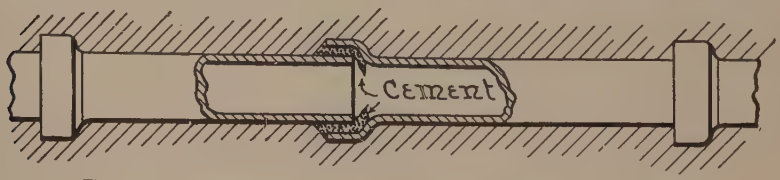


FIG. 69.—Danger of Cement Projecting inside Drain Pipe.

rough surfaces, against which various substances contained in the sewage passing through the pipe may collect.

It often happens that pipe of too large size is used for the house

sewer. It is true that it is almost as serious a matter to use too large pipe for horizontal drains and sewers as to use too small pipe. If the pipe is of proper size the sewage flowing through it passes out more rapidly, and with greater scouring action than if running sluggishly at the bottom of a pipe of large diameter. Thus, in Fig. 70 it may readily be seen that as the waste in the smaller pipe

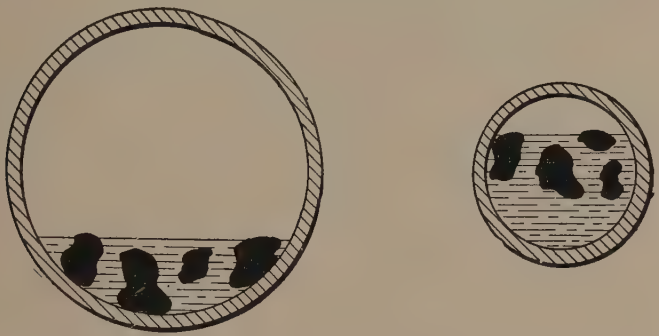


Fig. 70.—Flow of Drainage through Large and Small Pipes.

more nearly fills it than the same amount of waste in the larger pipe, such scouring action must certainly be greater in the small pipe. The solid matter carried by the sewage in the larger pipe has greater opportunity of lodging on the surface of the pipe also. Therefore, if a 5-inch pipe will perform the work in an entirely satisfactory manner it is obviously unwise to use a larger size.

The great danger in the use of earthenware pipes is that they may crack or be broken or that the joints may not be tight, under which conditions the surrounding soil becomes polluted and earth

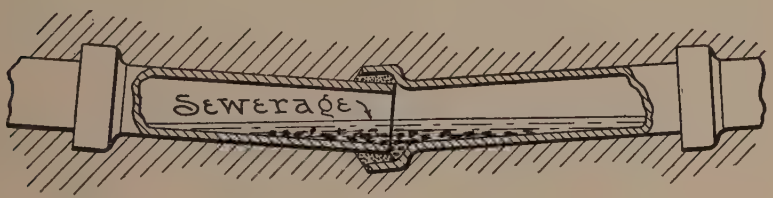


Fig. 71.—Settling and Breaking of Earthenware Pipes.

works into the drain, as in Fig. 71, eventually causing stoppage and the backing up of the house sewage. For this reason an earthenware drain or sewer should not be laid less than 3 feet beneath

the surface, or within 25 feet of any well or other source of water supply.

A restriction now laid down by nearly all plumbing ordinances is that no house sewer or drain shall receive sewage from any other house. In many cities two systems of sewers are now maintained, one for the disposal of house drainage, the other for surface water. Under these conditions the rain leaders should not be connected either into the house drain or sewer. Where there is no double sewage system, however, it is allowable to connect the rain leaders into the house sewer and often allowable to connect them into the house drain. When connected into the house sewer, each rain leader should be trapped, in order to prevent direct communication with the house and public sewers.

The main trap is sometimes placed on the house sewer, but it is better to locate it inside the foundation wall on the house drain, where it is more accessible, and often less susceptible to the action of frost.

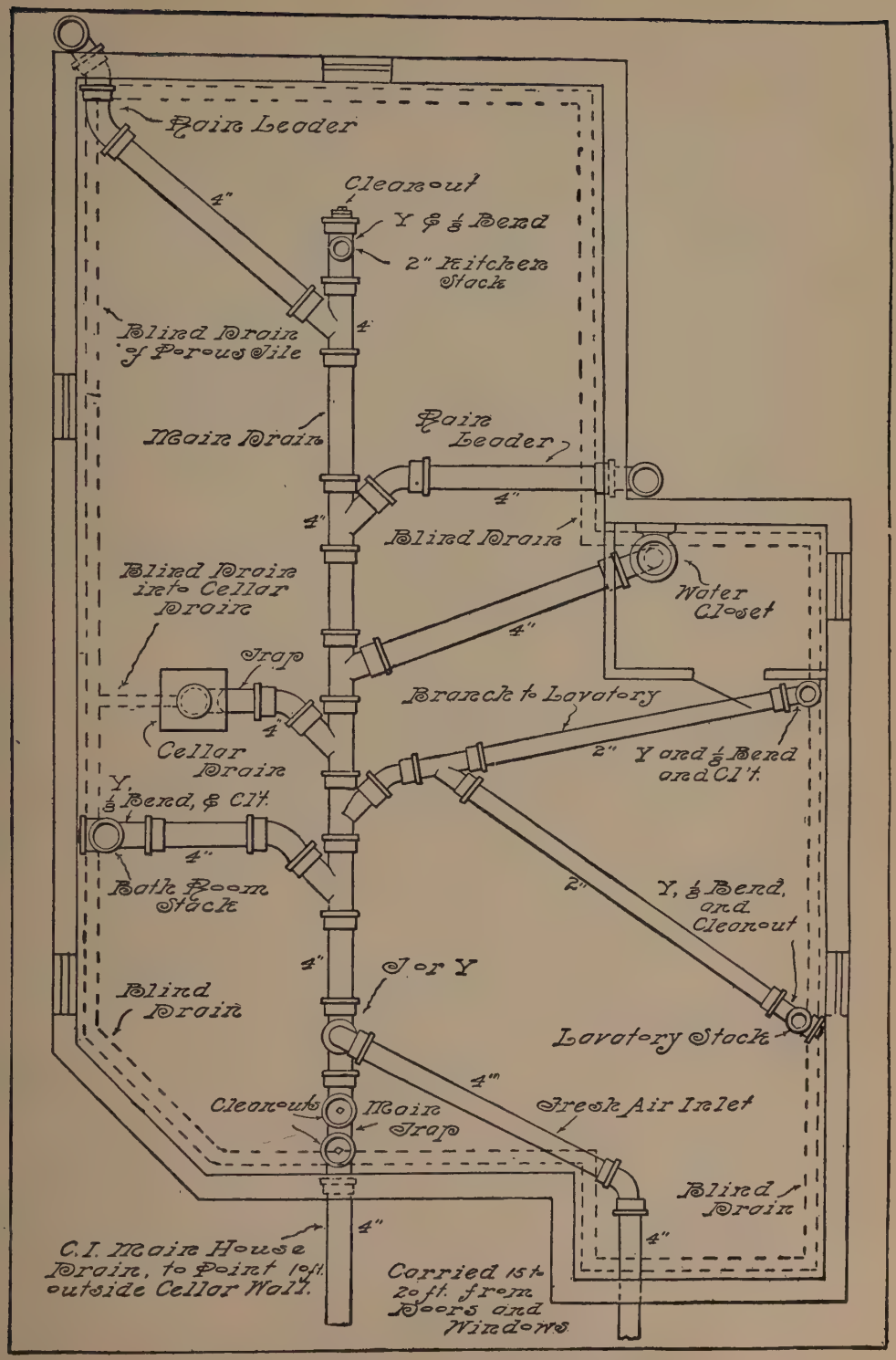


FIG. 72.—The House Drain and Its Connections.

CHAPTER X

THE HOUSE DRAIN

The house drain is that part of the horizontal soil piping of the drainage system which receives all soil, waste, and drainage pipes of the house. In Fig. 72 is shown a plan view of a house drain, with its various connections, which may be referred to in relation to some of the following considerations.

As previously stated, it connects with the house sewer at a point 5 to 10 feet outside the foundation walls. This provision is made in order that in the event of the breaking of the house sewer, which is generally of earthenware pipe, sewage may not be able to leech back through the foundation walls into the basement

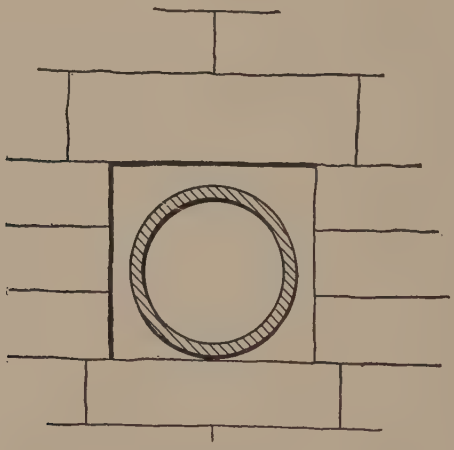


Fig. 73.—House Drain through Cellar Wall.

or cellar. The house drain should never be of earthenware pipe, the proper material for this work being either cast or wrought iron pipe. Wherever the house drain is run underground nothing but extra heavy cast-iron pipe should be used, wrought iron being especially susceptible to chemical action and decomposition when

used underground. Special provision should be made in constructing the foundation wall, to allow a passage through for the house drain. This is a point, the importance of which seems to be but little appreciated. The settling of the foundation walls is liable to crush or crack the pipe at this point unless the danger is guarded against. Figs. 73 and 74 show the proper method of construction. The opening should be constructed with a capstone across the top, and with space on all sides of the pipe.

If the drainage system is to be provided with a main house trap it is best to place it as close to the point where the house drain passes through the foundation wall as possible. There is much to be said for and against the use of the main trap, the subject being of such importance that a special chapter will be devoted to its consideration. The house drain should have a grade of one half

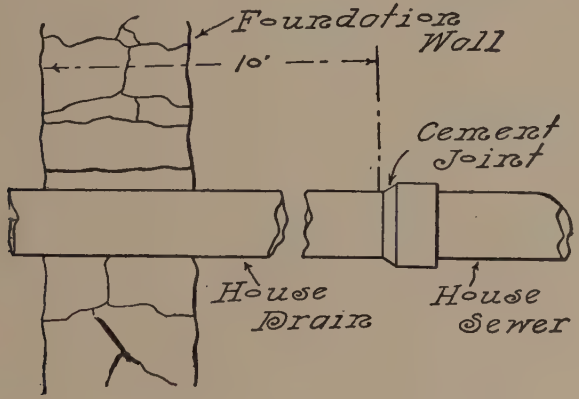


Fig. 74.—House Drain through Cellar Wall.

inch to the foot wherever possible, but in no case should it be less than one quarter inch. This provision applies to all soil and waste pipes also.

In running the house drain and, in fact, all other cellar or basement piping, it is always better practice to hang the piping from the timbers, exposed to view, than to run it underground. The running and supporting of soil piping thus installed may be seen in Fig. 75, the supporting of such lines being made by means of straps and hangers firmly secured to timbers, and by means of brick or stone piers resting securely on the cellar bottom.

This, of course, cannot always be done, especially if fixtures are located in the basement or cellar. Some cities require all underground drainage pipes to be inclosed in a boxing of chestnut planking. This requirement is a good one, but it may be said that it is followed in comparatively few cases. Into the house drain are connected not only the soil and waste stacks but also cellar drainage pipes, rain leaders, yard drains, etc., unless separate sewers are provided for surface and subsoil water, in which case

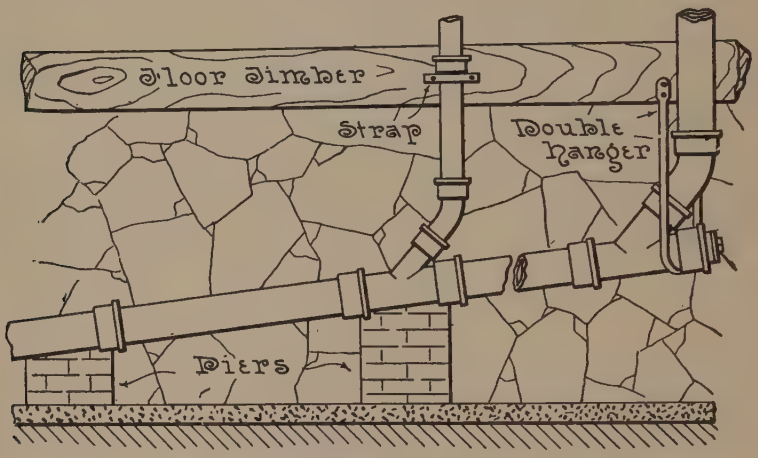


FIG. 75.—Running and Supporting of Exposed Cellar Piping.

the three last-named pipes would enter the surface-water house drain.

In Fig. 76 is shown an illustration of the house drain, with the several lines of soil and drainage pipes entering it. All branches leading into the house drain should be made by means of Ys. Tees should never be used for this purpose, and T-Ys are objectionable on horizontal piping. The Y is preferable, for the reason that waste is carried into the house drain by means of it in a less abrupt manner, obviating to a large extent the splashing of the waste against the sides of the pipe opposite the entrance. The splashing naturally causes substances in the waste to collect about the entrance of the branch, which will result in impeding the flow not only in the branch but in the house drain as well. Wherever right-angle turns are made in the piping, whether it be on hori-

zontal or vertical lines, the change in direction is made by means of a Y branch and one-eighth bend.

In Fig. 77 are shown several examples of the proper methods of making changes in direction in running soil pipe, and in Fig.

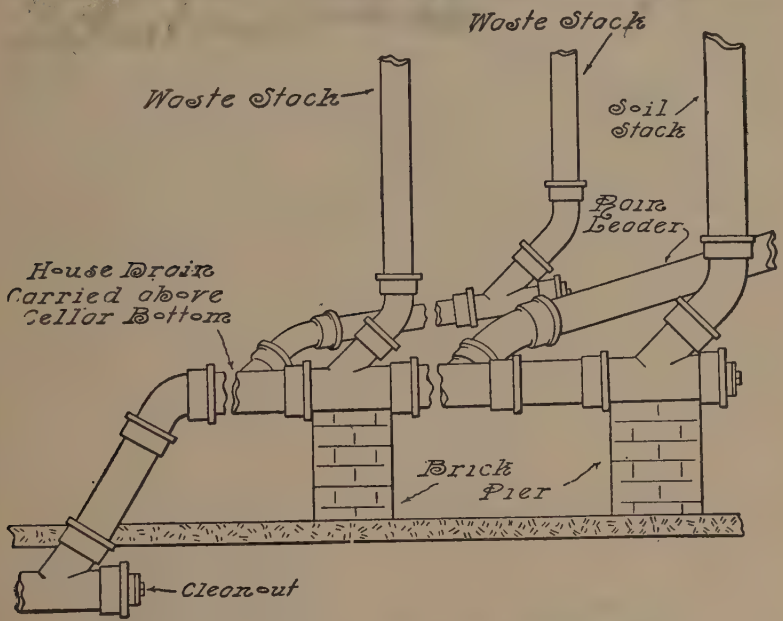


Fig. 76.—The House Drain and Pipes Discharging Into It.

78 are to be seen examples of similar work, in which changes in direction are improperly made. The reasons for considering the connections in Fig. 77 preferable to those in Fig. 78, are those which have been given above.

In Fig. 76 the connections of the waste and soil stacks into the house drain are examples of the methods of connection of Fig. 77. A cleanout should be used at the end of each horizontal run, as seen in Fig. 76.

The supporting of soil piping is a very important matter, one of those points, by the way, which is very liable to be overlooked, both by the plumber and by the architect. It is not an uncommon thing to see the house drain supported from the cellar timbers by rope and wire, or run on the face of the foundation walls with no

other support than wooden pins driven into the crevices. Such methods are entirely wrong. Under each vertical line of soil or

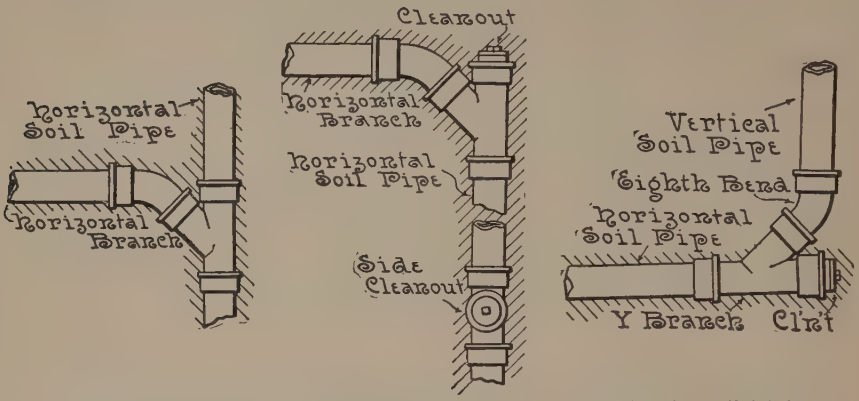


Fig. 77.—Correct Methods of Making Changes in Direction in Soil Piping.

waste pipe, at the point where it enters the house drain, a firm foundation of brick or stone should be provided to sustain the

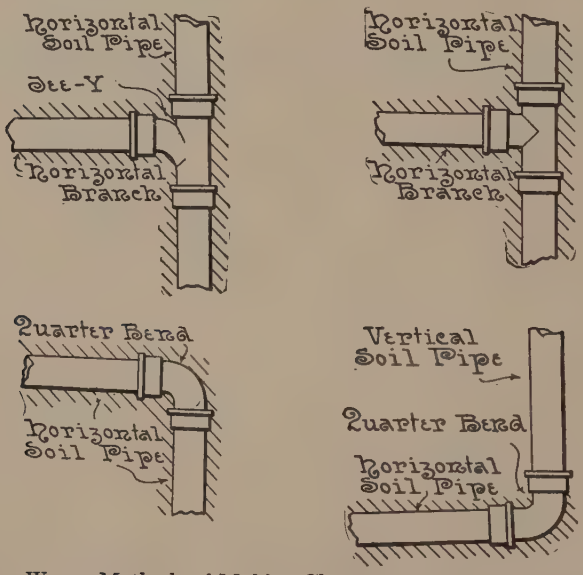


Fig. 78.—Wrong Methods of Making Changes in Direction in Soil Piping.

weight, which in the case of high buildings is often very great. Vertical lines should be supported at each floor by means of

wrought-iron bands placed under the pipe hubs, and securely screwed to the timbers. Another method of supporting vertical lines is shown in Fig. 79, from which it will be seen that the pipe is so cut that at each floor it rests upon a hub. Entire dependence for support should not be made upon this method, however.

Each line of horizontal pipe that is hung from the basement ceiling or cellar timbers should be supported at each length. Support is provided by means of pipe hangers of wrought iron. These hangers should be made in the form of the letter U, so that each end may be fastened to the timber by screws. Pipe hooks should never be used for this purpose, as they can be fastened only at one end, and lack sufficient rigidity. Great damage is often done to

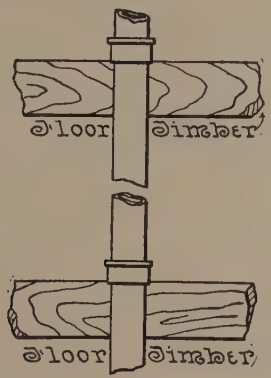


FIG. 79.—Vertical Line of Soil Pipe Supported by Hub at Each Floor.

lines of cast-iron pipe by settling, due to their own weight, a danger which may be almost entirely obviated by the proper supporting of the pipe. Another large factor in the weakening of lines of cast-iron pipe, in imperfect joints, etc., is the settling of floors and foundations.

The cellar drainage and subsoil-drainage systems are so closely allied to the main drain that it will be well to consider them in connection with the present subject.

The cellar drain is usually of 4-inch pipe and receives not only the surface drainage of the cellar, but the subsoil drainage also. The drain is formed by a deep well made in the cement cellar bottom, the hub of a half-S cast-iron trap being cemented into the

bottom of the well. The surface of the concrete cellar bottom is formed so that from all directions it pitches down toward the cellar drain. Just inside the foundation walls and extending completely around the building a gutter is formed in the cement bottom and carried into the drainage well at its top. By means of the graded bottom and the gutter, all water on the cellar bottom, due to leakage through the walls, leakage of pipes and cocks, etc., may be conducted into the cellar drain.

Beneath the cellar bottom the subsoil drain is laid. This is constructed of porous tile without hub and spigot, and laid with

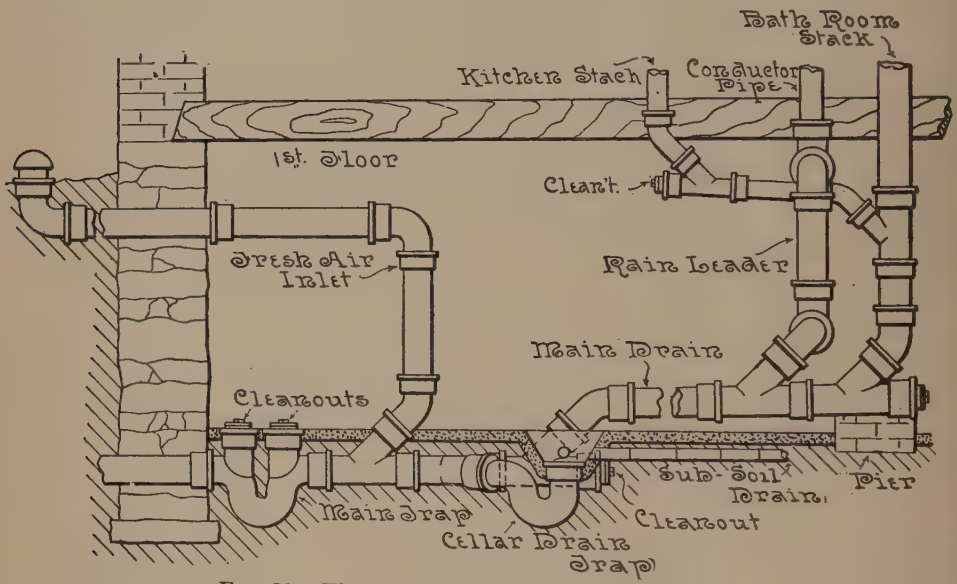


Fig. 80.—The House Drain and Its Connections.

loose, open joints, entirely around the cellar, and from the sides of the cellar into the center of it, wherever necessary. This drain is carried into the drainage well at as low a point as possible, and above the trap. Such a drain is usually employed only where the cellar bottom is damp or wet, and is not usually necessary where the soil is light or sandy.

The drainage well is usually located close to the house drain, the trap connecting into the main through a Y branch. There is danger in the use of the cellar drain, that its trap seal may be

broken by evaporation, in which case, if there is no main trap on the house drain, gases and odors from the sewer may enter the cellar or basement through the cellar drain. It is therefore well to provide the trap with a trap screw which may be used to close the opening into the drainage well during periods of drought, when sufficient subsoil water does not enter the trap to maintain a seal. The trap screw may be found of value in some cases, to prevent flooding of the cellar in the event of stoppage of the house drain, or backing up of the sewer. To overcome the danger of loss of seal, in part, at least, it is well to make a deep seal trap by the use of three quarter bends. This provides a very deep seal, which

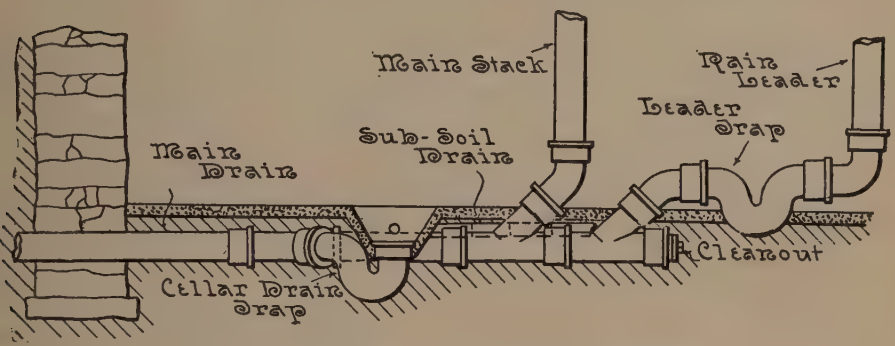


FIG. 81.—The House Drain and Its Connections.

is not easily broken. Such a trap should not be used, however, on any drain carrying other than clear water.

Fig. 80 shows the house drain of a system provided with main trap, and Fig. 81 the house drain of a system which is not thus provided. In each illustration are shown the connections of the cellar drain and subsoil drain, rain leaders, and soil and waste branches.

Fig. 82 shows some features of the testing of the house drain and its connections. In making the water or the smoke test, all openings must be closed before the test can be made, as shown in this illustration. Water is generally admitted, in the water test, through a specially constructed testing plug, which is often placed in the fresh-air inlet opening, owing to its convenience to the water connection. Besides the regular testing plugs and the plug with the water connection, a double testing plug, such as shown in Fig.

82, is generally needed, and a trap-testing plug also. The latter is shown in Fig. 83. A sectional view of the common testing plug

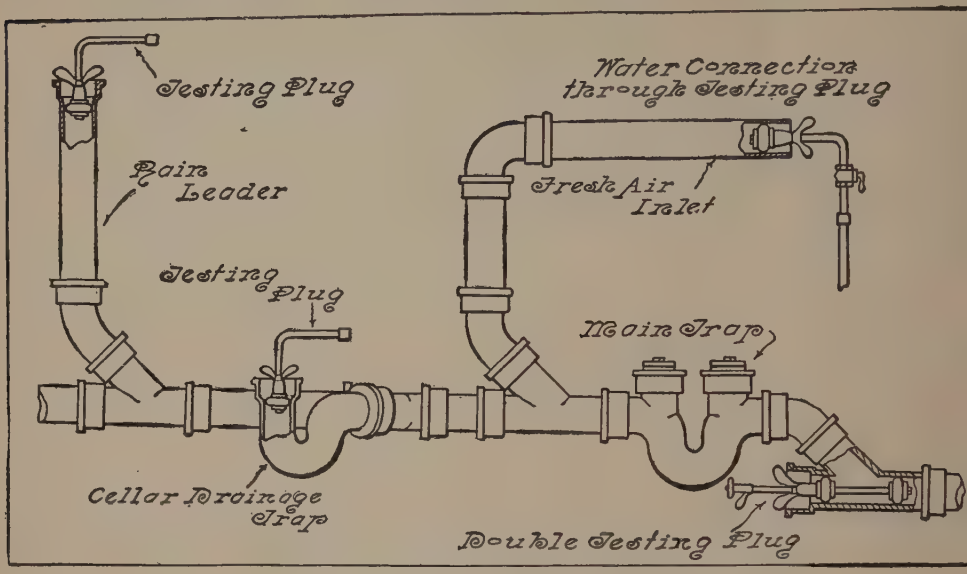


Fig. 82.—The Soil Piping in Readiness for the Water Test.

is shown in Fig. 84, and a sectional view of the double testing plug in Fig. 85. Another very desirable form of testing

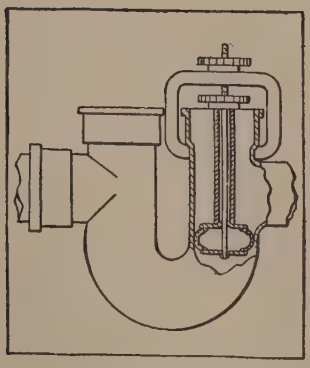


Fig. 83.—Testing Plug for Running Trap.

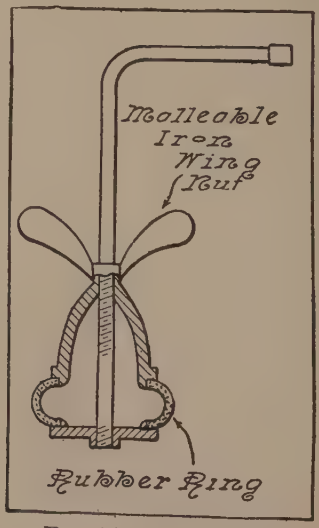


Fig. 84.—Testing Plug

plug, capable of holding very heavy pressures is illustrated in Fig. 86.

The single testing plug of Fig. 84 operates by the expansion, against the sides of the pipe, of a heavy rubber ring, which is ex-

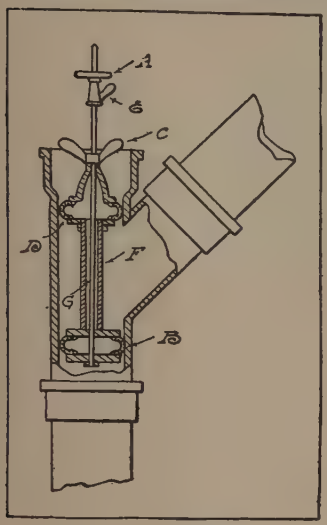


Fig. 85.—The Double Testing Plug.

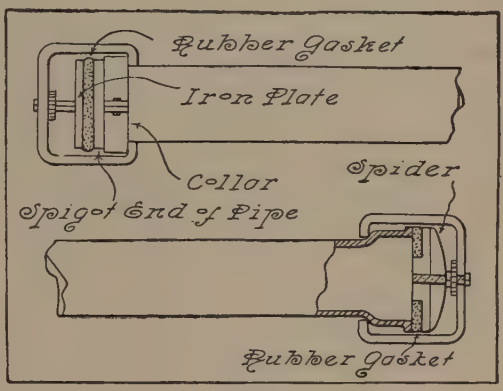


Fig. 86.—Special Testing Plugs.

panded by being compressed between an iron plate and a wing nut working on a screw. The operation of the double testing plug is as follows: The hollow piece F connects the plug D and the plug B

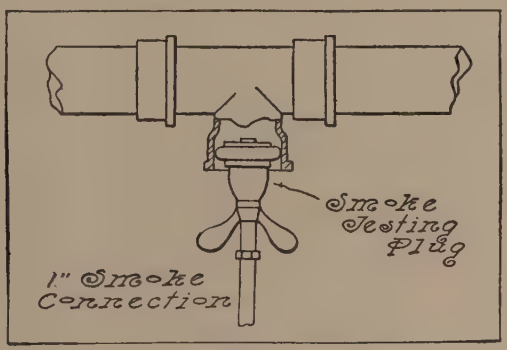


Fig. 87.—Smoke Testing Plug.

rigidly, and inside of it the rod G works. When the wheel A is turned against the nut E, it expands the plug B, and the plug D is

expanded without disturbing the other plug, by turning up the nut C.

Figs. 87 and 88 show methods used in giving the smoke test. For the stopping of openings, ordinary testing plugs may be used. In admitting smoke to the system, however, the method shown

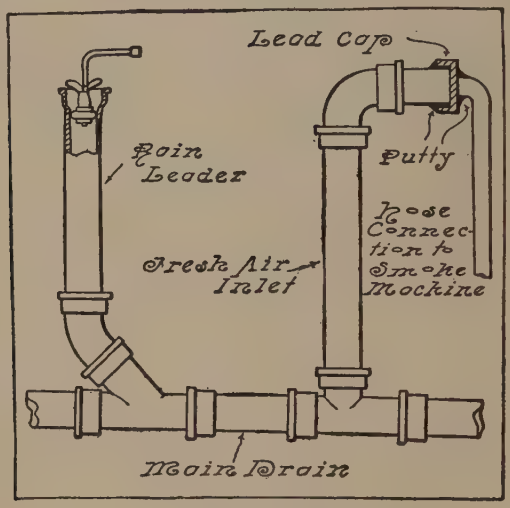


FIG. 88.—Plumbing under Smoke Test.

in Fig. 88 is generally used. Smoke-testing plugs which admit smoke through them, such as in Fig. 87, are also very handy for this purpose.

In "Modern Plumbing Illustrated," * by the author of this work, the subjects of water, air, peppermint and smoke tests are taken up very comprehensively, in all their details, in connection with both large and small work.

*"Modern Plumbing Illustrated" by R. M. Starbuck is published by The Norman W. Henley Publishing Co., 2 West 45th Street, N. Y. Price, $5.00.

CHAPTER XI

SOIL PIPING—ROUGHING-IN

The term soil pipe is used in a popular manner to designate all iron drainage piping, and it is also applied to the cast-iron piping used on the vent system. As a matter of fact, soil pipe is that part of the iron pipe of the drainage system through which the waste from water-closets flows. Other pipe, even though of the same size as the soil pipe, but carrying waste from other fixtures, is called waste pipe. However, the term soil pipe has come to be used so universally to designate all cast-iron pipe, whether used as soil, waste, or vent, that it will be more convenient to refer to it occasionally in this general way.

In Fig. 89 is shown a system of soil piping to which reference will be made later. In this system the main back-air or vent pipes are of cast iron. Wrought iron is being used very largely for this purpose at the present time, and it appears to be replacing the cast iron on this part of the system, in many sections.

In fact the use of wrought-iron pipe for vent work has become almost universal. Long, straight lines of wrought-iron pipe are more quickly run than cast iron, and closer connections can be made.

Several matters which might properly be considered here have already been taken up, such as the supporting of horizontal soil piping, etc. Vertical lines of soil and waste pipe should be supported at each floor by a clamp placed under the hub of a pipe or fitting, and firmly screwed to the timber. This support not only prevents the settling of the stack, but also prevents any side motion of the pipe.

All first-class plumbing ordinances now require the use of extra heavy cast-iron pipe on the drainage system in preference to standard pipe. The reason for this is that the standard pipe being much lighter has more sand holes and defects than the extra heavy.

Unless the standard pipe is cast perfectly, one part of the circumference will be very thin, while the section directly opposite will be correspondingly thick. When in this condition it takes only a slight blow to break the pipe. In the cutting of standard pipe and in the calking of joints, split lengths of pipe and split fittings are much more liable to result than in the use of extra heavy pipe. Many times such defective pipe and fittings are not cast aside as they should be, but made use of, the defects being patched up with tar so that they may not be detected. Principally to make such practices impossible, some ordinances demand the use of soil pipe which has no asphaltum coating.

The weights of different materials used on the plumbing system are, viz.:

Weights of Cast-Iron Pipe

2-inch	Standard	C.-I.	Pipe	Weighs	$3\frac{1}{2}$	lbs.	per	foot
3-inch	"	"	"	"	$4\frac{1}{2}$	"	"	"
4-inch	"	"	"	"	$6\frac{1}{2}$	"	"	"
5-inch	"	"	"	"	8	"	"	"
6-inch	"	"	"	"	10	"	"	"
2-inch	Extra Heavy	"	"	"	$5\frac{1}{2}$	"	"	"
3-inch	"	"	"	"	$9\frac{1}{2}$	"	"	"
4-inch	"	"	"	"	13	"	"	"
5-inch	"	"	"	"	17	"	"	"
6-inch	"	"	"	"	20	"	"	"
7-inch	"	"	"	"	27	"	"	"
8-inch	"	"	"	"	$33\frac{1}{2}$	"	"	"
10-inch	"	"	"	"	45	"	"	"

Weights of Wrought-Iron Pipe

Diameter.	Thickness.	Weight per ft.
$1\frac{1}{2}$ inches	.14 inch	2.68 lbs.
2 "	.15 "	3.61 "
$2\frac{1}{2}$ "	.20 "	5.74 "
3 "	.21 "	7.54 "
$3\frac{1}{2}$ "	.22 "	9 "
4 "	.23 "	10.66 "
$4\frac{1}{2}$ "	.24 "	12.34 "

Diameter.	Thickness.	Weight per ft.
5 inches	.25 inch	14.50 lbs.
6 "	.28 "	18.76 "
7 "	.30 "	23.27 "
8 "	.32 "	28.18 "
9 "	.34 "	33.7 "
10 "	.36 "	40.06 "

Weights of Brass Pipe

Diameter.	Thickness.	Weight per ft.
1½ inches	.14 inch	2.84 lbs.
2 "	.15 "	3.82 "
2½ "	.20 "	6.08 "
3 "	.21 "	7.92 "
3½ "	.22 "	9.54 "
4 "	.23 "	11.29 "
4½ "	.24 "	13.08 "
5 "	.25 "	15.37 "
6 "	.28 "	19.88 "

Weights of Lead Pipe

Diameter.	Weight per ft.
1 inch	2 lbs.
1¼ "	2½ "
1½ "	3 "
2 "	3½ "
3 "	4½ "
4 "	6 "

As will be seen later, in the description of the Durham plumbing system, whenever wrought-iron pipe is used for drainage purposes, the fittings used in connection with it should be of cast iron. They should be of the style known as extra heavy cast iron, recessed, and threaded drainage fittings. These fittings should also be used on main vent lines of wrought iron, although it is true that in many cases they are not used on such work.

For fixture and branch vents of wrought iron it is permissible to use galvanized cast or malleable steam and water fittings. In the use of short nipples on either drainage or vent work, special care should be taken in order that they may not be split or crushed in any way. When the nipple is of such length that the distance between the two threaded ends, that is, the part unthreaded, is less than $1\frac{1}{2}$ inches, the nipple should be of " extra strong " pipe.

The term " roughing-in " is applied to the plumbing system when it has reached the point where the first test is to be applied. The " roughing-in " includes the entire soil-pipe system, house drain, soil and waste stacks, main vent lines, all branch wastes and vents. In fact, the " roughing-in " includes the entire plumbing system with the exception of exposed work above the floor, that is, the fixture itself, its trap and waste to the floor, and the vent connection to the wall. Figs. 89 and 110 will give an idea of what is meant by " roughing-in."

In roughing-in, wherever waste pipes are to be run of more than six feet in length, lead pipe should not be used. The use of lead for drainage and vent work is fast going out of date, cast and wrought iron and brass taking its place. The labor involved in lead work, properly constructed, is greater than in the use of other materials; it is less rigid; long lines of lead pipe are liable to sag and form traps; and lead pipe is sometimes subject to the attack of rats, the generally accepted idea being that in their attack they are attempting to reach the water which they hear flowing through the pipes.

To such an extent has lead work been replaced in many parts of the country that the trade of the plumber of to-day has changed almost entirely from that which the old-time lead worker followed. There was a time not many years back when the plumber made his own traps, bends, etc., and a time when lead soil pipe was used. All that is now changed, and although the older plumbers may not agree to it, it would seem that this great change is for the better.

In the running of horizontal soil, waste, and vent pipes, they should have a grade of at least one-quarter inch to the foot, and more than this amount is preferable. Wherever possible, each fixture should have a separate entrance into its stack. This is a practice which is by no means generally followed, and it certainly does

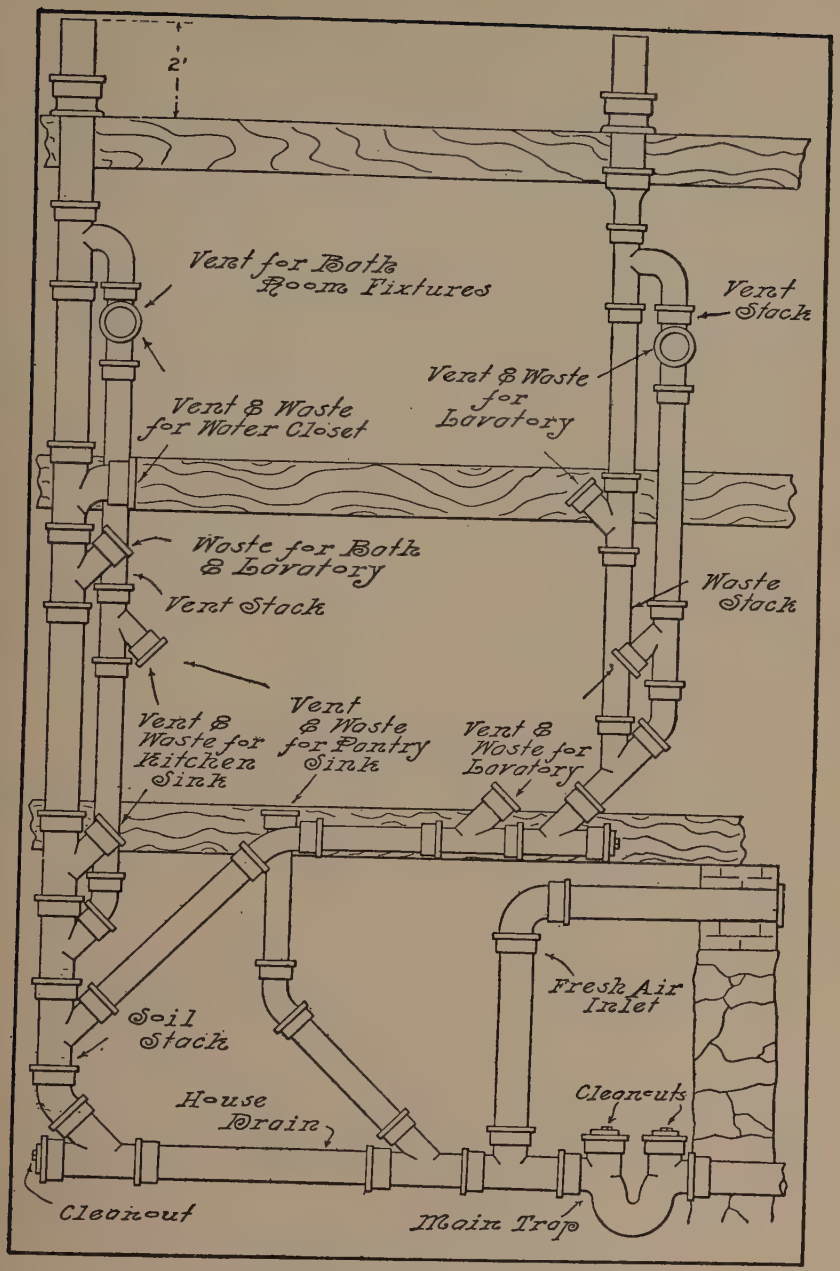


FIG. 89.—System of Soil Piping.

not receive the attention which it deserves. Referring to Fig. 90, it will be noted that the bath tub and lavatory are served by the same line of waste pipe. This is not to be considered an unsanitary practice, and many times it would be almost impossible to construct the work otherwise. If the waste pipe should become stopped at any point between the lavatory connection and the stack, it may readily be seen that both lavatory and bath would be affected. If each had a separate connection the stoppage of one

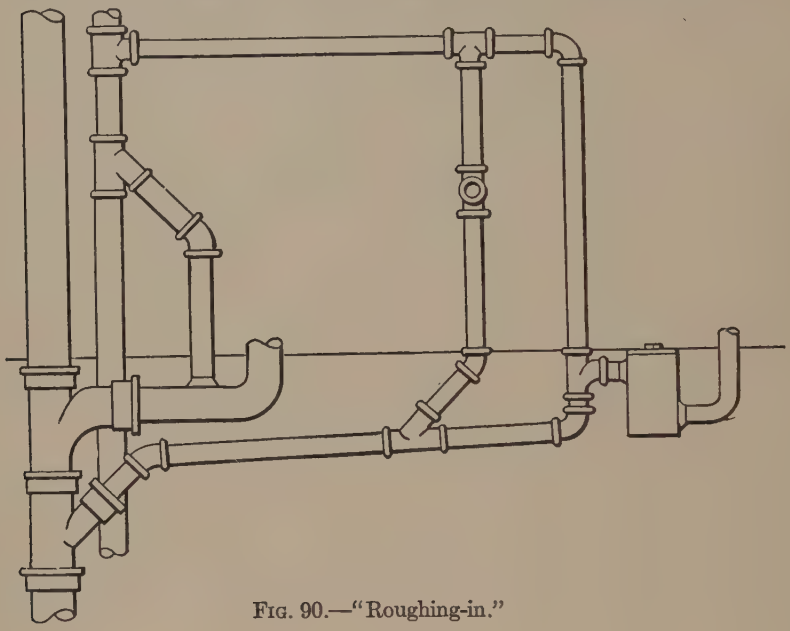


FIG. 90.—"Roughing-in."

waste would not affect the other. It may be stated further that very often the plumber might obtain separate entrance for each fixture, but in a vast majority of cases the work is taken under contract, and the betterment of the work by making separate entrance would result in additional expense to him. In other instances the architect might easily lay out the work and make locations of pipes and fixtures such that separate entrances might easily be made. For instance, in the floor plan of Fig. 91, the relative locations of fixtures and stack are such that each fixture may waste independently into the stack, as will be seen in Fig.

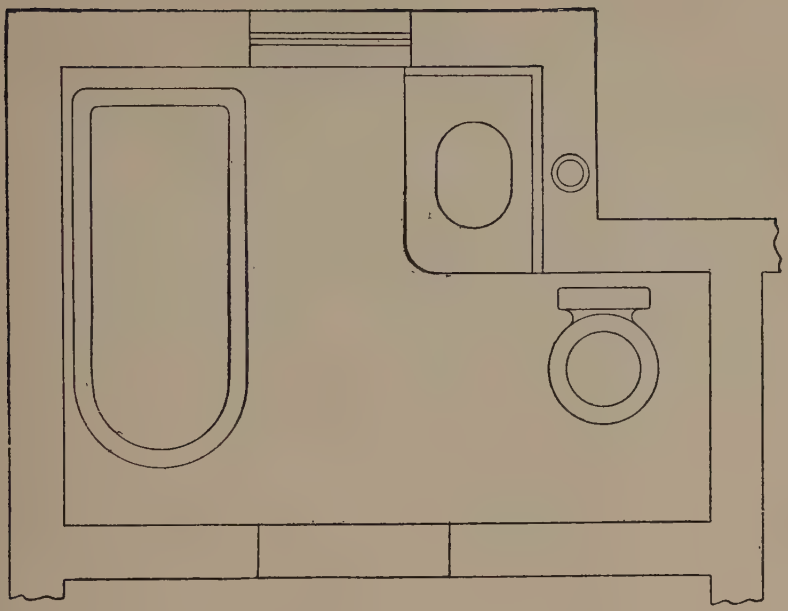


FIG. 91.—Floor Plan of Bath Room.

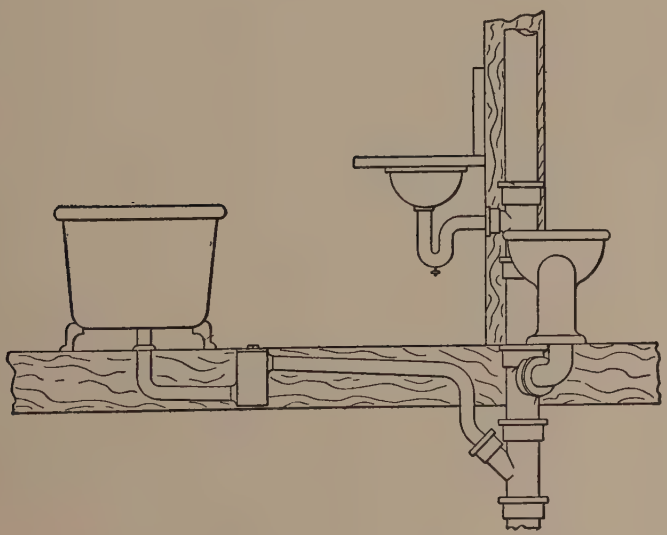


FIG. 92.—Separate Entrance of Each Fixture into Stack.

92, which shows an elevation of the work of Fig. 91. Mention should be made of the practice which is almost universal in certain sections, of connecting the waste pipes from lavatories and bath tubs into the water-closet lead bend. This is a practice followed by a surprisingly large number of plumbers who pride themselves on the excellence of their work; and it is generally allowed both by the architect and the plumbing inspector.

Nevertheless, it is a poor practice, and never to be followed if it is possible to construct the work otherwise. While the practice is bad under any conditions, certain methods of performing this work are far better than others. In Fig. 93 two different methods of

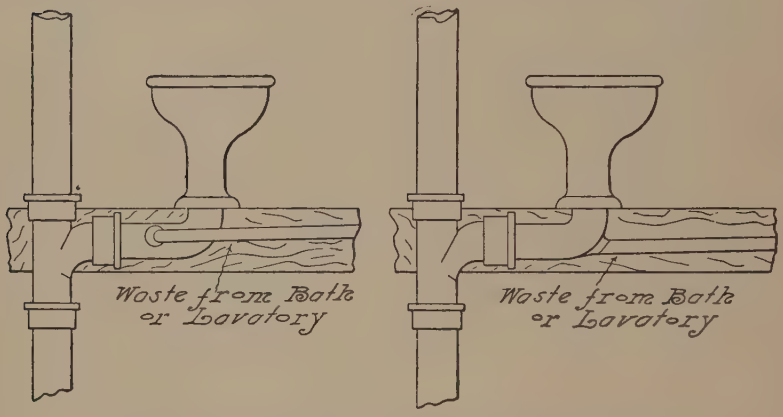


Fig. 93.—Connection of Waste Pipe into Lead Bend.

making the connection are to be seen, into the heel of the bend, and into the upper part of the horizontal arm. The latter is far preferable to the former. When connected into the heel, the opening is in such a position that paper and other matter may fall into the entrance and result eventually in its stoppage. When so connected the connection is often made so low that soil and other waste has an opportunity to set back into the waste pipe whenever the water-closet is flushed. When connected as high up as possible on the horizontal arm, however, neither of these faults is encountered.

The connection of a fixture waste into the vertical part of the lead bend is preferable to the heel connection, but not so good as into the horizontal arm.

In any of these connections, however, another serious fault is to be found. In the wiping of the connection onto the lead bend, small spines of solder are extremely liable to project through into the interior of the bend and cause much trouble by the catching of paper, etc., upon them. When other fixture wastes connect into the lead bend, another serious feature presents itself in the fact that the stoppage of the lead bend results in the disabling of all fixtures connected to it.

No fixture waste should ever pass through more than one trap before reaching the house drain, the effect of double trapping being to cause air-lock between the two traps, which acts to impede the flow of waste through the pipe. Where an abrupt change is made in the direction of a pipe, on the drainage system, a cleanout should be used at that point. End cleanouts should be used as seen in Fig. 89, at the ends of horizontal lines. In running such horizontal lines no dead end should ever be left. By dead end is meant an extension of drainage pipe beyond the last entrance of waste into it. Thus, in Fig. 89, if the house drain were extended beyond the point where the cleanout is, and no waste entered this extension, it would become a dead end. The dead end not only serves no useful purpose, but soon fills with filth, and aids materially in fouling the drainage system.

In the running of drainage pipes, whether on main or branch lines, all offsets should be made at 45° if posssible, this giving a much easier passage for the waste than an abrupt offset, such as 90°. Formerly it was customary in making an opening into a pipe for a new fixture waste or branch line of waste to use a saddle fitting, such fitting usually being held in position over the opening cut in the pipe, by wrought-iron clamps, the joint between the fitting and the pipe being made with putty. For obvious reasons this practice is now prohibited, it being a most unsanitary method.

The proper method of performing such work is to break out the pipe at the desired point, and insert the necessary fitting. On such work as this the use of insertable fittings has in recent years become universal. There are several such fittings on the market, and in Fig. 94 two of them are shown. It being desired to insert the fitting A to receive a new line of waste, the pipe at this point is broken out and the spigot end of the insertable fitting calked in.

The fitting A is then set in position, and the part F unscrewed until its hub and the spigot of A are together. The several joints are then calked. The part B of the insertable fitting is provided with a coarse cast thread in which the thread on G works. Such a fitting saves much time and makes more satisfactory work, for in many instances in the insertion of fittings into old pipe, several

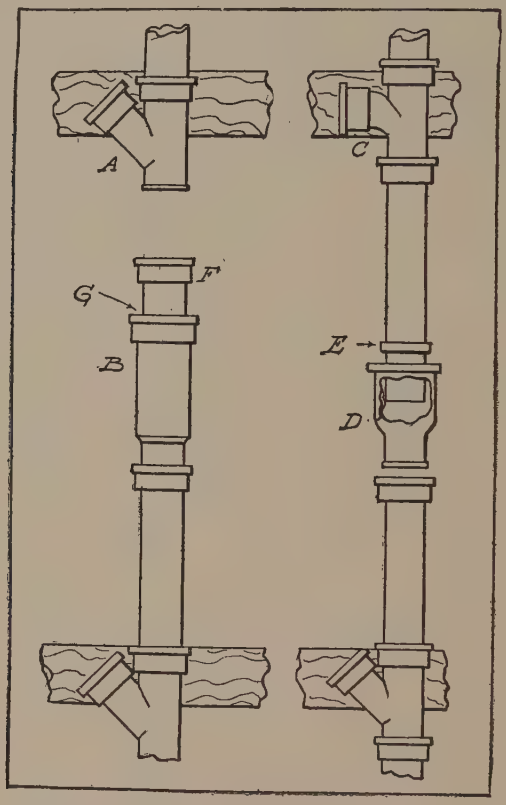


Fig. 94.—The Use of Insertable Fittings.

joints on each side of the fitting have to be sprung in order to get the new fitting into position, and it is then necessary to recalk these joints. The other insertable fitting of Fig. 94 is made on a different principle. It consists of a long hub of large diameter, D, into which a ring of soft lead, E, may be calked when the fitting C has been placed in position.

From what has been stated in previous chapters, it will be seen

that in any plumbing system it is necessary that at least one 4-inch pipe shall pass through the roof. Whenever a vent passes through the roof it should extend at least two feet above it.

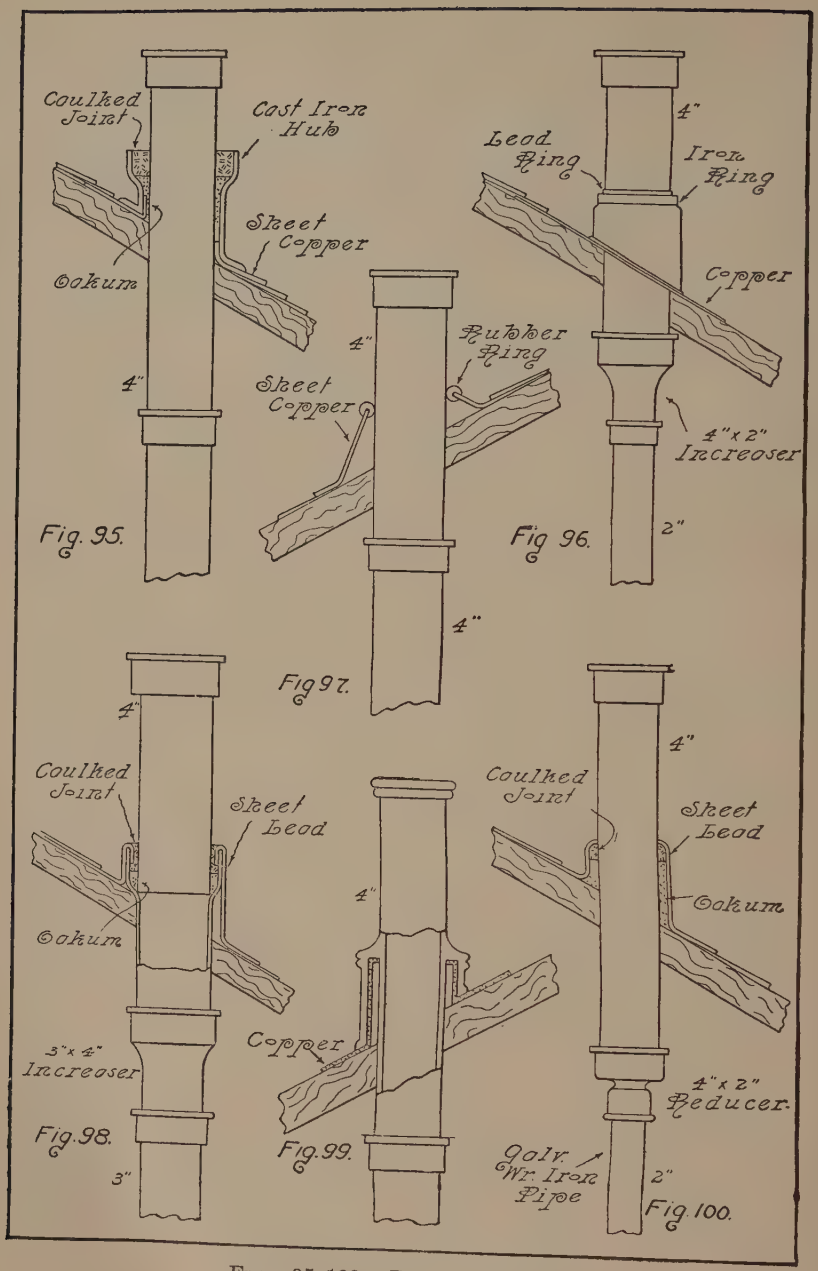
If a flat roof is used for other purposes than the mere covering of the building, such pipes should extend at least five feet above it.

Whenever a branch line of soil or waste pipe is extended 15 feet or more from the main soil or waste stack into which it is connected, the branch should be carried through the roof.

Soil, waste, or vent pipe should ordinarily not be carried on the outside of any building. Such a prohibition is imperative in a cold climate, but there is not so much to be said against it when practiced in a warm climate, where there is no trouble from frost to be feared. When a building adjoins another of greater height having doors or windows overlooking the lower building, the openings of all roof pipes coming through the roof of the lower building should be at least 12 feet from windows and doors in the higher building, and no roof pipe should be closer than 6 feet to any chimney opening. It is quite customary to use a wire basket or other protector to cover the open end of a roof pipe, but there is something to be said against the practice. The meshes of the basket being somewhat close together furnish opportunity for the collection of frost over the basket in cold weather, resulting in the entire or partial stoppage of the vent opening. The practice, however, would not be open to objection in warm climates and would act as a protection against the entrance through the roof pipe of leaves, etc.

The roof connection is made in a variety of ways, either with sheet lead or with patented roof flanges. In Figs. 95 to 100 are shown several of these connections. Fig. 95 shows a device that is, perhaps, used more extensively than others. It consists of a cast-iron hub riveted to a copper flange, the latter being nailed to the roof as shown.

The roof flange of Fig. 96 is also a patented device, consisting of a lead body attached to a copper flange, having at its upper end an iron ring into which a lead ring is calked. The use of the soft lead ring obviates the necessity of carrying a pot of molten metal to the roof with which to make the lead joint. Fig. 97 shows a flange which may be used on roofs of any pitch, the joint being made by a



FIGS. 95–100.—Roof Connections.

rubber ring which encircles the pipe. Unless the surface of the pipe is smooth, the rubber is not liable to make perfect contact around the entire circumference, in which case leakage of water down the outside of the pipe will follow. Moreover, the life of rubber is not of long duration, when exposed to the air and weather, and soon loses its elasticity. Fig. 98 shows a method often followed by the workman in making his own roof flange, as does Fig. 100 also. In Fig. 98 the sheet lead is flanged over and down into the

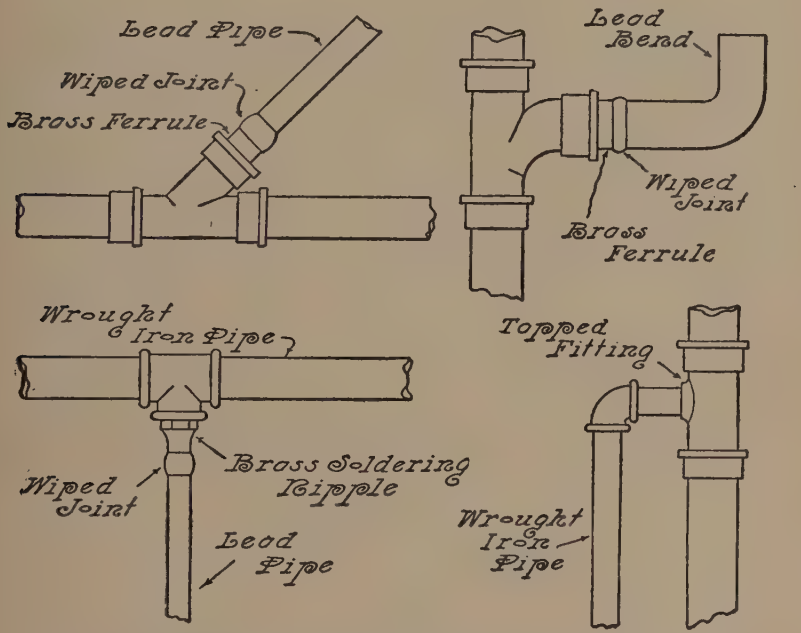


Fig. 101.—Connections between Lead-, Wrought- and Cast-Iron Pipes.

hub. When the lead joint is poured and calked, a very satisfactory piece of work results. In Fig. 100 the sheet lead forms an upright collar around the pipe, and after the joint is poured and calked the end of the collar is rounded over as shown. Fig. 99 shows a very satisfactory roof flange, in the use of which leakage of roof water down the pipe is an impossibility. A very popular feature of this device is the fact that no lead joint has to be poured and calked on the roof. This is a point much appreciated by the workman, as it is often difficult, particularly on steep roofs, to melt and pour

the metal for a calked joint. The copper collar fitting up into this device is loose, being held rigidly only at the roof. Consequently, the settling of the roof does not tear away any part of the connection and result in leakage. In several of the illustrations various reducing fittings are to be seen.

Plumbing ordinances lay down special rules for the making of connections between different kinds of pipe. In Fig. 101 are to be seen the common connections, and other connections will be shown later on, in the consideration of special subjects, such as the Durham system. Lead pipe is connected to cast-iron pipe by means of a brass ferrule, to which the lead pipe is connected by a wiped joint, the ferrule being calked into the pipe. One of the figures shown illustrates the lead bend connected in the same way. Lead pipe is connected to wrought-iron pipe by means of a brass soldering nipple. One end of the nipple is threaded and screws into the fitting on the wrought-iron pipe, the lead pipe connecting with the other end by means of a wiped joint. Sometimes in place of the wiped joint a cup joint or an overcast joint is used. The cup joint is made by swelling out the end of the lead pipe, dropping the pipe, ferrule, or nipple into the bell end thus formed, and with a soldering copper the two are soldered together. The overcast joint is made by the use of a soldering copper, the solder being formed around the joint in the form of a wiped joint, and then smoothed over with a rasp or file to give it the smoothness and symmetry of a wiped joint.

Neither of these joints is allowed by plumbing ordinances, although they are used to a large extent in sections that are not under plumbing restrictions. The wiped joint is much stronger and more perfect than either the cup or overcast joint.

Wrought-iron pipe is connected to cast-iron pipe by means of tapped fittings, into which the wrought-iron pipe may be screwed. Wrought iron is also sometimes calked into the hubs of cast-iron pipe if the sizes happen to come right. If not, a coupling screwed onto the end of the wrought-iron pipe will often allow it to be calked.

Before leaving the subject of "roughing-in," the matter of fixture wastes should be considered, as the concealed work on the fixture wastes is constructed during the "roughing in." It will

therefore be appropriate to insert at this point the following table of sizes of fixture wastes:

Fixture.	*Size of Waste. Inches.*
Water-closet	4
Slop sink	3
Pedestal urinal	3
Floor and yard drains	3
Horse stall	2
Urinal trough	2
Laundry tubs (3 to 6 parts)	2
Laundry tubs (1 to 3 parts)	1½
Kitchen sink	1½ or 2
Pantry sink	1½
Bath tub	1½
Sitz bath	1½
Foot bath	1½
Shower bath	1½
Safe wastes	1½
Lavatory	1¼
Group of lavatories (2 or 3)	1½
Drinking fountain	1¼
Refrigerator	1¼

The cellar piping is a most important matter of " roughing-in." There are two common methods of running this piping, the most common being that of Fig. 102, in which the pipe is concealed underground. The other method is to run it exposed, in which case it is generally carried on the cellar timbers. The latter method (Fig. 103) is the preferable one, and when so run support should be given it according to the method of Fig. 104, but never according to Fig. 105. An important feature in installing cellar piping is to insure making all cleanouts readily accessible. Such provision is to be noted in both Fig. 102 and Fig. 103. Many times the piping cannot be run so that it is practicable to support it from the cellar timbers because of its distance from them. In that case the piping should be supported on brick or stone piers, as in Figs. 106 and 107, especially under vertical stacks. When the piping

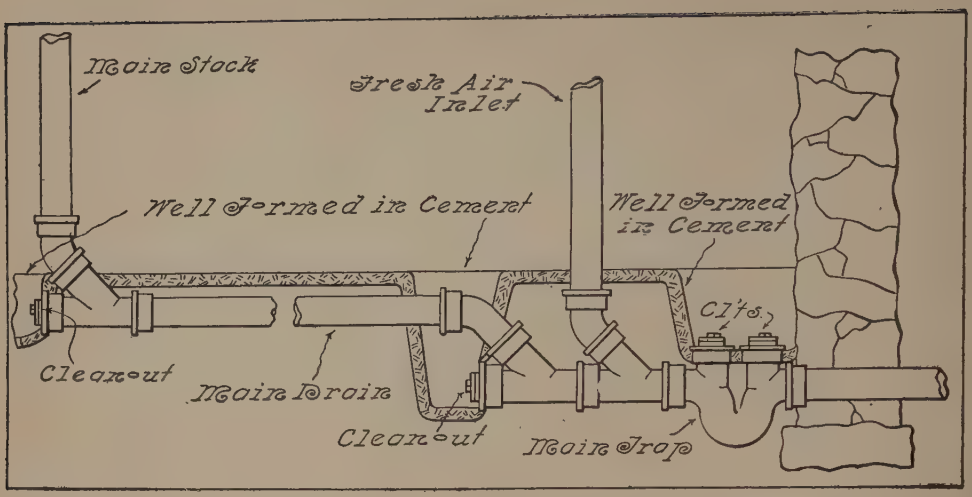


Fig. 102.—Good Method of Running House Drain Underground.

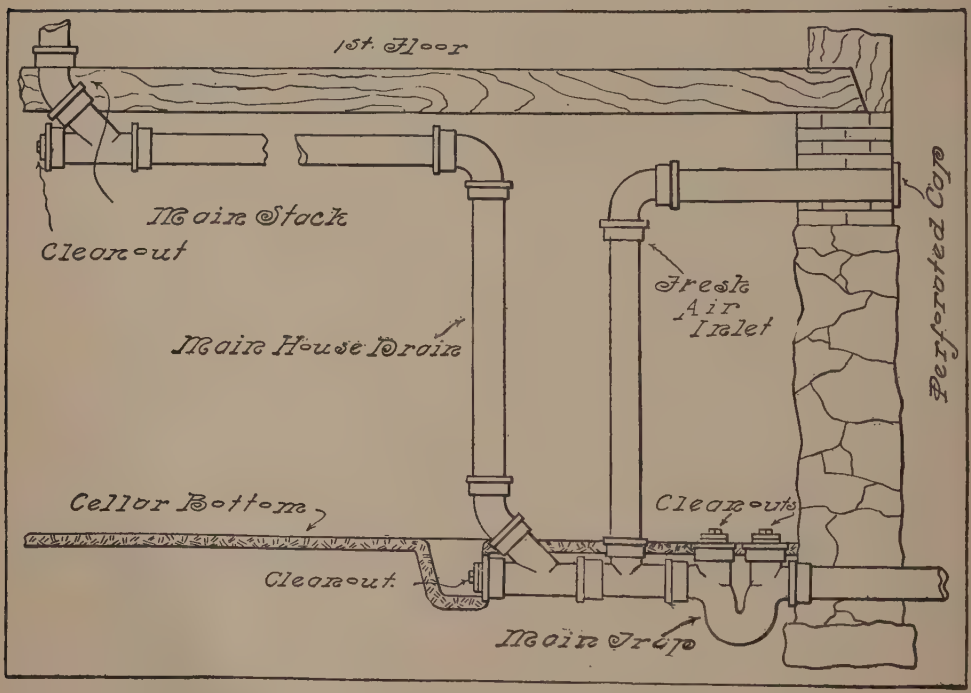


Fig. 103.—Line of House Drain Run Overhead.

is run horizontally through finished rooms and exposed to view the neatest method of supporting it is by means of special pipe-supporting fittings, as in Fig. 108.

The supporting of vertical lines of pipe is shown in Fig. 109. The best method consists of the use of wrought-iron bands or clamps at each floor.

Having completed the consideration of the general subject of

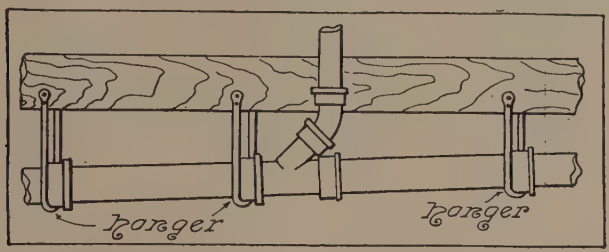


Fig. 104.—The Use of Hangers in Supporting Horizontal Pipe.

soil piping, it will be of advantage to many of the readers of this work to devote some space to certain features pertaining to the practical construction of soil-pipe work, taking up first the operation of calking a lead joint.

In general, this joint is made by first tamping oakum into the hub of the soil pipe, then in pouring molten lead into the hub, after

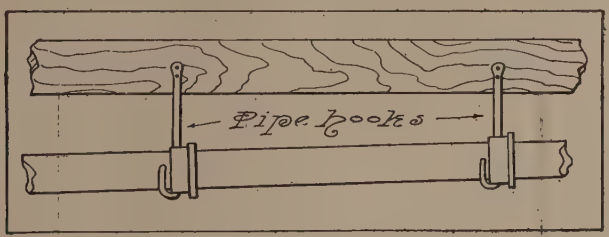


Fig. 105.—Poor Practice—Use of Pipe Hooks in Supporting Horizontal Pipe.

which it is calked. To many a plumber the simple act of putting in the oakum, tamping it down a little, and then pouring on top of this a little molten lead seems to constitute the whole subject of making a calked joint. There is much more than this to be considered, however, if a successful piece of work is to be done. It is a fact that in many tests applied to the "roughing-in" almost as

much time is consumed in repairing defects in the soil piping which the test brings to light as was consumed in the construction of the work. Much of such trouble comes from imperfectly calked

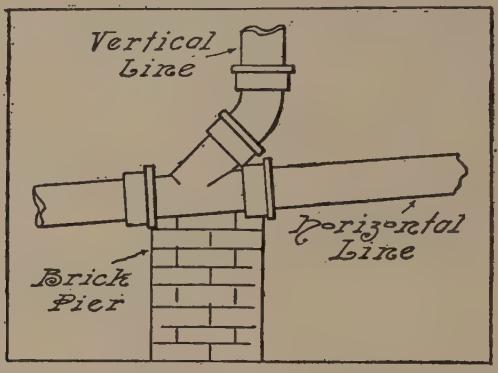


Fig. 106.—Horizontal Line of Pipe Supported by Pier

soil-pipe joints. In making a calked joint the oakum should never be dropped in loosely, as is often done. It should first be formed into a tight roll a little larger than the width of the joint to be

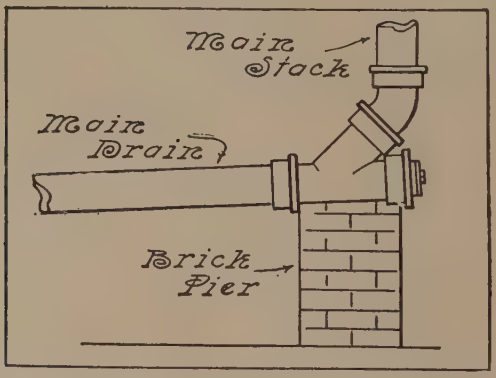


Fig. 107.—Vertical Line of Pipe Supported by Pier.

made. The plumber usually gets his oakum into the right condition by rolling it on his knee. The oakum is then forced into the hub with a yarning iron and firmly calked with a regular calking tool, so that a good foundation is made for the lead. In fact, if the oakum is properly calked, it should be nearly water tight before the

lead is poured. The oakum should fill the hub to within about an inch of the top. It is a mistake to use a great depth of lead, for the reason that while the effect of the calking might be felt at any depth, the really beneficial expansion of the lead is felt only through a comparatively small depth. If the lead is over an inch in depth, it does not feel the effect of the blow on the calking tool sufficiently to cause it to expand properly. As a consequence, the additional metal is of no real value, merely filling space which the oakum might fill at less expense. The lead should not be poured until the metal is hot. The same care does not have to be given to the melting of lead that is needed in melting solder, for the reason

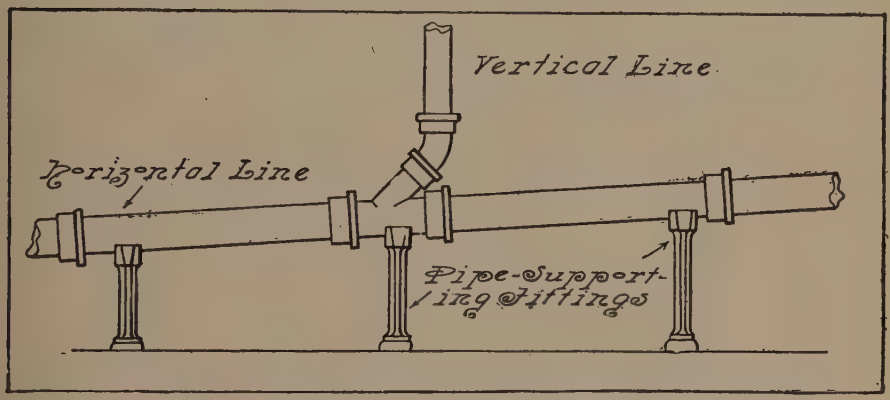


FIG. 108.—Horizontal Line of Pipe Supported by Pipe-Supporting Fittings.

that it contains no tin that may be burned up. It is well to heat the lead close to a cherry red. This heat insures the successful running of the metal, without the necessity of repouring. The lead should fill the hub. The lead is now ready to be calked, and before finishing this operation it is a good plan to thoroughly calk the outer and inner circumferences of the lead, this course insuring an expansion against the sides of the pipe, which are the points where defects are most likely to appear. Calking tools may be ground specially for calking each of these circumferences. When a joint calked as described is finished the hub will be full, whereas if the oakum had been dropped in or loosely calked, the lead, when calked, would have settled down below the top of the hub, necessitating a second pouring many times. When the lead is poured it should be

seen that no small fiber of oakum is left reaching up to the top of the hub, as this often is the cause of a leaky joint, the water finding its way along the fiber through the lead.

Another feature on which successful calking depends lies in the quality of the lead used. Calking lead should be as soft as possible,

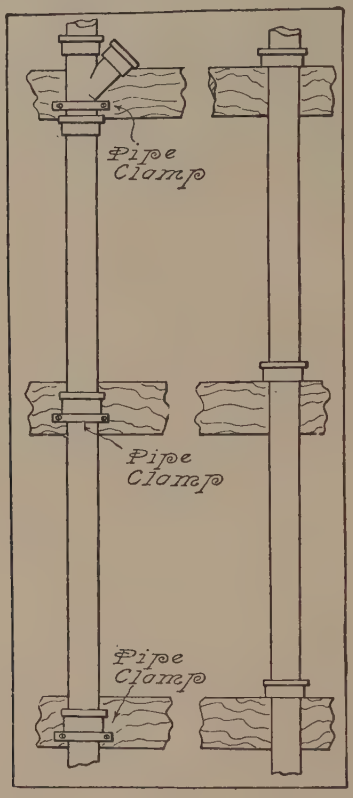


FIG. 109.—Supporting of Vertical Lines of Pipe.

and therefore free from zinc, solder, etc. For this purpose old lead pipe is often melted up, and may be easily made too hard by allowing the solder from old joints on the pipe to be melted with it. The calking of joints on vertical lines of pipe is straightforward work, but in the case of horizontal joints special means must be adopted to prevent the metal flowing out of the hub before it has an opportunity to cool.

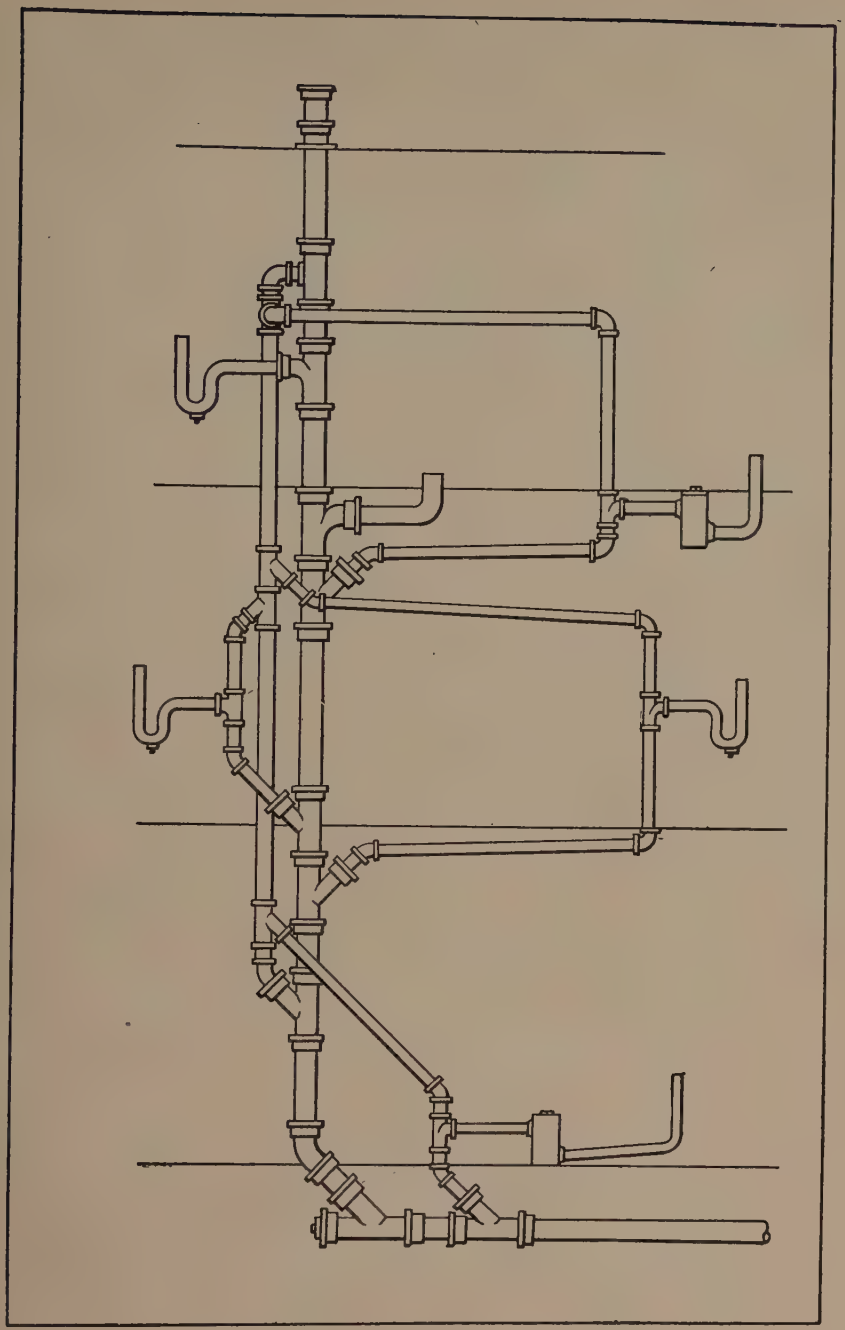


Fig. 110.—Plumbing System Ready for Water Test.

The old-style method consisted in winding a rope of putty, clay, or flax and putty around the pipe in such a way as to close up the opening between the hub and the pipe. A small opening was then made at the top to allow the metal to flow through. Now, however, special joint runners are generally used for this purpose. They are made of asbestos rope and provided with a special clamp for holding the rope in position and for forming a gate for the metal.

In connection with the calking of lead joints a great variety of tools are used. The plumber is generally very particular concerning his calking tools, and in order that they may be exactly suited to his individual requirements he very often has them made special instead of using the tools ordinarily carried in stock.

The illustration and use of special calking tools is taken up in Chapter I.

In Fig. 110 is shown a system of soil piping which constitutes the " roughing-in " of the plumbing system, and which has been made ready for testing. This system, with its cast-iron stack and galvanized wrought-iron vent work, is typical of the method of construction generally employed on such work, the use of wrought iron for vent work being now more universal than such work as shown in Fig. 89.

CHAPTER XII

MAIN TRAP AND FRESH-AIR INLET

The use of this trap is open for discussion, and its advantages and disadvantages have been debated more extensively probably than any other subject relating to the drainage system.

Its advocates have strong arguments in its favor and its opponents advance sound arguments against it.

When the main trap is made use of on the plumbing system it

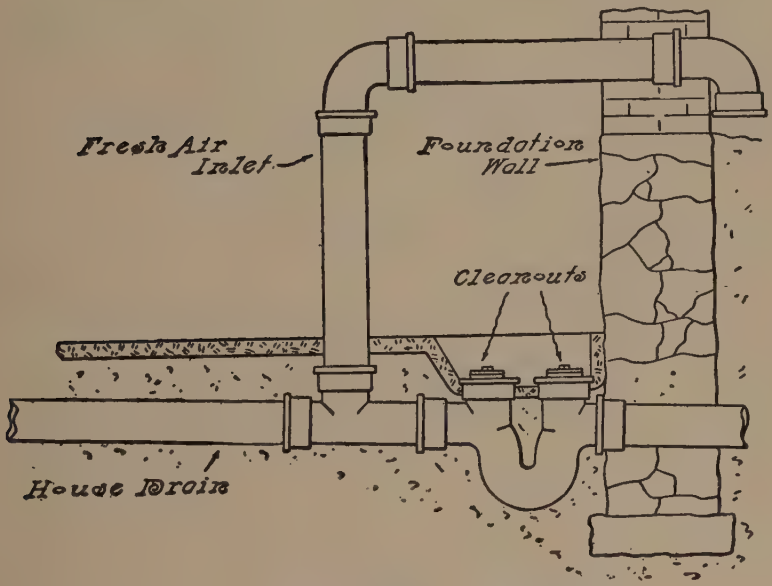


Fig. 111.—The Main Trap and Fresh-Air Inlet.

is located on the house drain and as close to the point where it leaves the building as possible. Fig. 111 shows the connections of the main trap and fresh-air inlet, the latter being a necessity wherever the main trap is used, as will be seen later. The purpose of this trap is to safeguard the building against the entrance into it

from the sewer of sewer air and gases. The chief argument against the use of the main trap is that each soil and waste stack passing through the roof should have an unobstructed path throughout its course to the public sewer, in order that it may act as a vent for the sewer. In other words, the non-use of the main trap is advocated in order that every roof connection in the town or city may become a part of a great ventilating system for the public sewer system. It is not to be denied that every system of sewers needs ventilation, and that better provision is needed than is generally provided. The closed, unventilated system without ventilation of any kind is undoubtedly an exceedingly foul and filthy affair and a source of great danger to the community.

It is a question, however, whether the use of the house plumbing system as a sewer vent is desirable, and it is a question whether other adequate means cannot be provided for performing this work with as great efficiency.

At present, in most cities, the chief means of sewer ventilation is through perforated manhole covers in the streets. Needless to say, the amount of ventilation provided in this way is entirely insufficient for the amount of work to be done, and in addition it may be said that in many cases the perforations of the manhole covers become filled with dirt and in the winter time with ice and snow. Moreover, the venting of sewers into public thoroughfares is an unsanitary practice, but one which the public has become accustomed to, and therefore gives small attention to. Other means than this should be provided. One plan has been advanced which would seem to have many valuable features. It has been proposed to erect at available high points on the sewer system large ventilating stacks through which to exhaust the sewers of foul air and to draw into them a supply of fresh air. This method would entail considerable public expense, but would seem to be an object worthy of the outlay, inasmuch as it affects the public health to a large degree. Such a method seems to be far preferable to venting the sewer at all points in the community, where in heavy weather gases are bound to settle down and become a source of danger to the entire people.

It may be a point not generally appreciated, but a fact, nevertheless, that there are very few plumbing systems that have been

in use for a period of years which are not defective in various ways. The settling of foundations and floors is bound to produce defective soil-pipe joints, and even result in the cracking of pipe and fittings in some instances. The action of the acids and gases from the house sewage often results injuriously to lead and iron work, and especially to wrought iron. Many other causes of defects in the plumbing system might be named, and it is safe to say that in a large majority of instances the plumbing system would fail under the tests applied to it when first installed.

The point of all this is that through the various defects in the drainage and vent system abundant opportunity is offered for the entrance of sewer air and gases from the sewer into the living rooms of the house.

The purpose of the main trap is to overcome this trouble and to prevent the occurrence of the same conditions from various other causes. For instance, the main trap prevents the entrance of sewer air through the cellar drain, floor drain, and other traps in the event of loss of seal. In the case of fixtures seldom in use the fixture trap often loses its seal through evaporation; fixture traps often lose their seals through siphonage and other causes. Danger is avoided under such conditions by the use of the house trap.

When water-closets are removed from their position, to be renewed or for the making of repairs, direct communication between the house and sewer results unless the main trap is used, as also in the case of repairs or renewals on the cast-iron drainage system, such as the inserting of fittings to receive the waste from new fixtures, etc.

These are a few of the many ways in which the house may become open to the entrance of sewer air, and the facts as presented certainly make a strong argument in favor of the use of the main trap. Some of the minor arguments against its use are the facts that it is liable to freeze when located in cold places, that it will close up with heavy substances in the sewage, and that it presents an obstruction to the free passage of sewage from the house. The two first-named arguments appear to have little weight, as practical experience shows that the trap seal seldom freezes, and that it is very seldom that a main trap becomes stopped up. The waste from the house is generally warm, and, with the exercise of good judg-

ment, the trap can be so located or otherwise protected that it need not be in danger of freezing.

To be sure, the trap prevents the outflow of sewage as rapidly as a free passage would allow, but this fact seldom is found to be the cause of special trouble, and the fresh-air inlet aids materially in the easy passage of the sewage.

The trap used under each fixture is liable to stoppage and presents an obstruction to the rapid outflow of waste, but the facts are never used as an argument in favor of discontinuing the use of the fixture trap. No more should the same arguments avail in discontinuing the use of the main trap.

The first point named in opposition to the use of the main trap is without doubt, then, the strongest argument against it, and really the only one, and it would seem that the weight of argument is in favor of the use of the main trap.

In connection with the main trap the fresh-air inlet is always necessary. For the ordinary house having a 4- or 5-inch house drain the fresh-air inlet should be 4 inches.

Its purpose is twofold. Its chief end is to convey into the drainage system a supply of fresh air and to create a circulation of air through the drainage system and through the roof pipes. It also makes the passage of waste through the house drain easier, as it prevents air lock between the outflowing waste and the seal of the main trap by venting the house drain at a point near the trap.

An objection to the fresh-air inlet is that, in the case of a down draught, foul odors may be driven out through the inlet. These odors, however, do not come from the sewer, and are therefore not so much to be feared. Valves of various kinds have been used to admit fresh air and to prevent the escape of foul air, but in general they are not to be depended upon and are usually looked upon as a failure. Because of the occasional escape of odors the fresh-air inlet opening should never be located within 20 feet of any door or window. This often necessitates the running of the fresh-air inlet out into the lawn, yard, or to the curb, in which case, at the point where it comes to the surface a ventilating cap should cover its end in order that nothing may enter or be thrown into it. The fresh-air inlet is strictly for purposes of ventilation, and under no circumstances should drainage of any description be allowed to

enter it. When carried only to the outside face of the foundation wall the fresh-air inlet should be provided at its end with a perforated cover, or, as shown in Fig. 111, with a bend pointing down.

The main trap is sometimes located on the house drain or house sewer underground. When so located the chief precaution necessary is to make it easily accessible, and this may best be done by placing it in a well at such depth as to be protected from the frost, as shown in Fig. 112. When placed underground the fresh-air inlet for the main trap is generally carried straight to the surface,

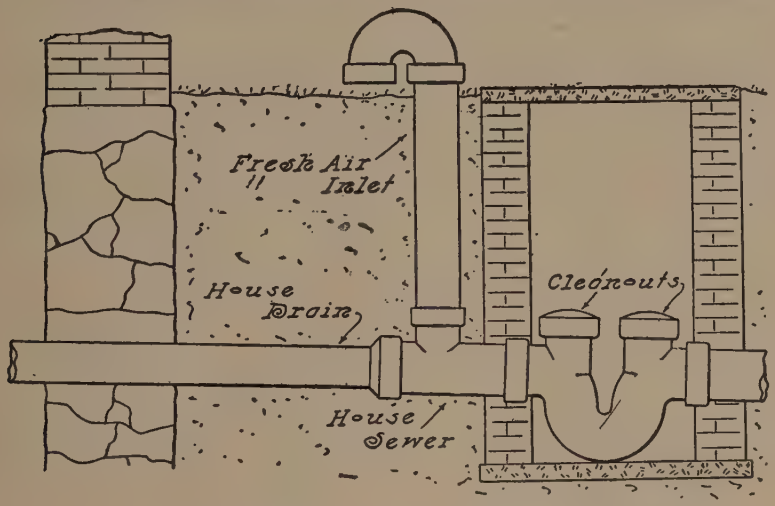


Fig. 112.—The Main Trap when Located on House Sewer.

as in Fig. 112, in which case its open end should be protected by a bend.

The best practice calls for the connection of the fresh-air inlet to a tee or Y placed next to the main trap. Until within a few years the custom was to connect it into the cleanout hub on the house side of the trap. This method not only deprived the trap of one of its cleanouts, but brought cold air so directly upon the seal of the trap that the water often became chilled.

Even though the trap seal should not become cold enough to freeze, the mere chilling of it should be avoided, for when sewage becomes chilled the grease contained in it separates out and collects on the cold surfaces exposed to it.

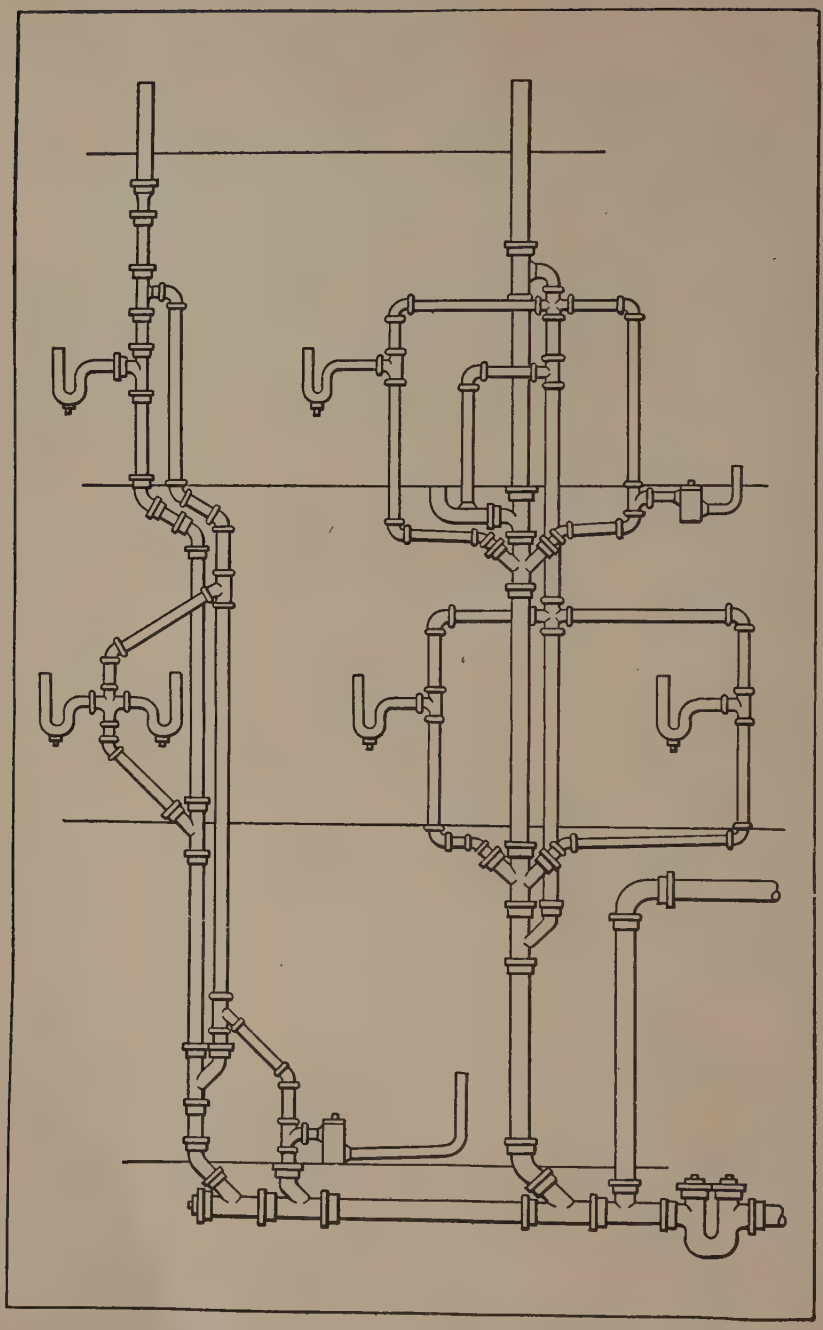


FIG. 113.—"Roughing" for the Plumbing System, with Main Trap and Fresh-Air Inlet.

In order to avoid this trouble the fresh-air inlet is now generally connected as mentioned above, thus making the entrance of cold air less direct. The fresh-air inlet should always be connected on the house side of the main trap. If connected on the sewer side it would act as a direct vent for the sewer and be unable to perform the duties for which it is designed. The fixture trap vent, however, should always be connected on the sewer side of the trap. There is sometimes confusion on the part of people respecting the connection of these two forms of vents, but there should not be, if due consideration is given to the different purposes of the two.

In Fig. 113 is shown an elevation of a plumbing system which is provided with a main trap and fresh-air inlet.

In this illustration is shown only the roughing, the work at this point being ready for the water test.

CHAPTER XIII

FLOOR DRAINS, YARD DRAINS, CELLAR DRAINERS, RAIN LEADERS, ETC.

The subject of floor drains pertains more especially to large work of a public nature, such as public toilet rooms of hotels, schools, factories, etc., apparatus rooms and hose towers of engine houses, washrooms of stables, etc., and in general seldom appears in residence or other similar work. In general, the remarks on the cellar drain, made in a previous chapter, apply also to floor and yard drains.

Whenever a double system of sewers is provided, one for house drainage and the other for surface water, these drains should be connected to the surface house drain, but in the absence of the double system they may be connected to the house drainage system. Floor drains should be at least 3 inches in diameter and be provided with deep seal traps, with cleanouts of the same size.

An example of floor-drain connections may be seen in Fig. 114. The floor should be graded so that all water falling on it may run into the drain. It is very customary to use the drain having a bell trap as shown in detail in Fig. 114. This trap is a very shallow one, whose seal is easily lost from evaporation. It is preferable to use a plain drain without the bell attachment and use a deep seal cast-iron trap, as shown. All yards, areas, or other similar surface should be provided with a drain similar to that of Fig. 114. Whenever connected to the house drain direct, each should be separately trapped. Two or more drains of this character may often be connected into one main, in which case each separate drain does not require a separate trap, but a trap placed on the main may be used instead to protect the several drains. It is often convenient also to connect floor and yard drains into rain leader pipes, under which conditions the trap on the rain leader offers sufficient protection without the trapping of each drain. In fact, connections of

this kind have an advantage over separate trap connections in the fact that when dependence is made on the one trap the several drains may be depended upon to renew and maintain its seal with much more certainty than a single drain could be depended upon to maintain the seal of its own trap. Stable wash racks or other wash racks from which waste, carrying sediment or solid matter, issues, should not be connected to any part of the drainage system

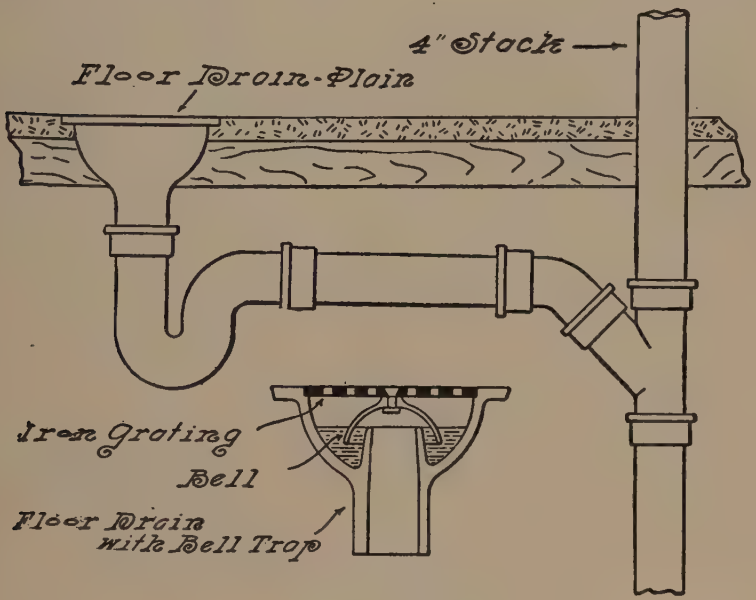


FIG. 114.—Floor Drain.

unless a catch basin with trap is provided to prevent such matter from passing into the drainage system.

All rain leaders should be trapped on plumbing systems which are not provided with a main trap, but on the trapped system the trapping of rain leaders is not necessary, as the main trap affords protection to the roof leaders. In general, the least number of traps possible to afford ample protection is preferable to the use of a greater number, as double trapping is attended with greater danger of stoppage and with a much slower outflow of sewage, owing to air lock between the traps. Whenever rain leaders are run to the roof inside the building they should be constructed of soil pipe,

but when run outside they may be of galvanized sheet iron to a point not less than five feet from the ground, at which point they should enter a soil-pipe branch. In Fig. 115 are shown the customary rain-leader connections. When the rain leader is run inside the building, of cast iron, the connection with the roof gutter

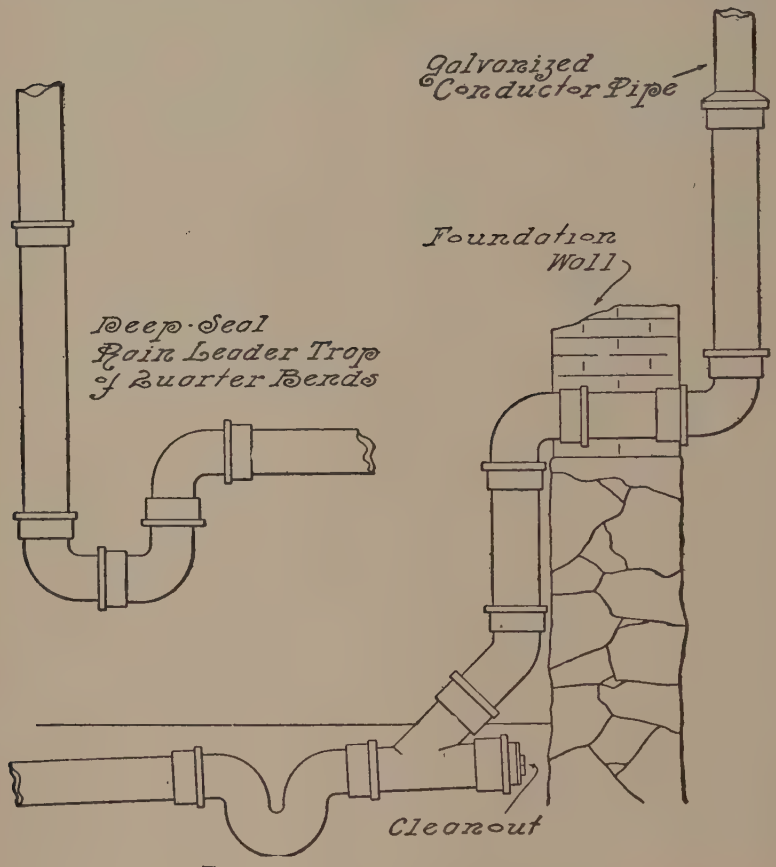


FIG. 115.—Rain Leader Connections.

should be made by means of a brass ferrule, calked into the soil pipe, to which is wiped the lead or copper pipe connecting with the gutter. The opening of the gutter connection should be funnel-shaped and provided with a wire basket as a protection against the entrance of leaves, twigs, etc., into the conductor pipe and drainage system.

When two or more rain leaders enter the same branch, and no soil or waste pipe enters between or back of them into the same branch, a single trap on the branch may take the place of a separate trap on each leader, this trap, of course, being placed on the sewer side of the leader entering nearest to the house drain. The size of rain leaders should depend on the amount of roof drainage each one is required to take care of, but should never be less than 3 inches in diameter. As already stated concerning cellar drainage, traps of floor and yard drains, rain leaders, etc., should have as deep a seal as practicable. The depth of seal is limited in the ordinary cast-iron trap, but a trap can be made, such as shown in Fig. 115, which will provide any depth of seal desired. The trap is constructed of quarter bends, and may be made of any additional depth by using a straight piece of pipe on the outlet leg of the trap between the two bends. A seal of great depth would be an unsanitary device if applied to the house-drainage system, as it would provide a lodging place for a large quantity of waste, which would soon putrefy and render the system more impure than there is any necessity for. The water passing through floor and yard drains and roof leaders is clear, however, and depth of seal need, therefore, not be limited. Drainage from fixtures should never be allowed to enter any of these drains.

In connection with the cellar work of the plumbing system, the use of the cellar drainer is a very important feature under certain conditions. It often happens that the street sewer is at such a high level that the house drain, in order to gain sufficient pitch, must be carried above the cellar bottom. In this event, it is clear that the cellar drainage into a catch basin supplied with a trap, such as described in a previous chapter, will not answer the purpose, as it is located so low that it cannot deliver into the house drain by gravity, in the ordinary manner.

The cellar drainer, of which there are several makes, is made use of extensively under these conditions. This device is generally operated by the pressure of water in the house supply system. In Fig. 116 is shown the connections for the cellar drainer and the manner in which its work is performed. Cellar drainers are made to act automatically. When the water accumulates in the catch basin in which the drainer is located it gradually raises a float.

When it has risen to a certain point it opens a valve, which admits the water supply, which discharges the water collected in the catch basin. This water is discharged into a sink installed for the purpose, or, if it so happens, into any similar cellar fixture which may be convenient. This sink should be trapped and vented just as any

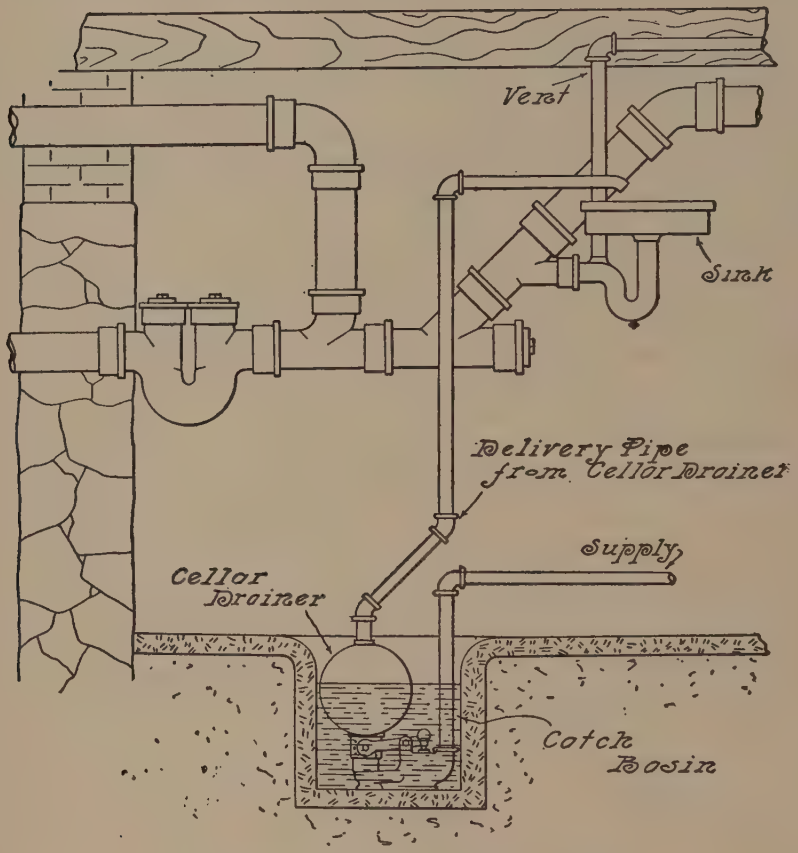


Fig. 116.—Connections for Cellar Drainer.

other house fixture. The action of the cellar drainer depends upon the creation of a partial vacuum by passing water or steam under pressure through a jet, thereby producing a suction which draws the water out of the catch basin or other receptacle into the discharge pipe, the pressure forcing it up to the point of delivery. It will be observed that both surface water and the water used in

operating the drainer are discharged. When the float falls it closes the valve and the device is ready for its next operation.

Some manufacturers claim that the cellar drainer will lift water through 12 feet, but it would appear that 8 to 10 feet is about the limit. Even so, however, the drainer covers a wide range of work. It is made in various sizes, capable of caring for 50 gallons to 1,200 or more gallons per hour. The minimum pressure required is generally about 15 lbs. The greater the distance through which the water is to be lifted the greater will be the amount of water necessary to operate the drainer. In addition to its use in connection with the drainage of cellars, it is often used in draining cesspools, wheel pits, catch basins, into which refrigerator lines discharge, and for many other purposes.

The subject of the disposal of sewage and surface water collecting at points below the sewer level has become a very important matter, and as it relates to large work, will be taken up at a later point, in a chapter devoted to that subject. It will readily be seen that in handling large volumes of drainage from public toilet rooms located underground, the use of any such device as the cellar drainer would be out of the question entirely, such work needing powerful apparatus working on a different principle, and often required to discharge many thousands of gallons per hour.

CHAPTER XIV

FIXTURE WASTES

ANYONE who is acquainted with the work of the plumber well knows that it is not fine fixtures and nickel trimmings that make up the sum total of a sanitary plumbing system. Indeed, the sanitary character of the plumbing system depends much more upon the manner in which the concealed piping is installed than upon that part of the work which is exposed to view. A bath room, for

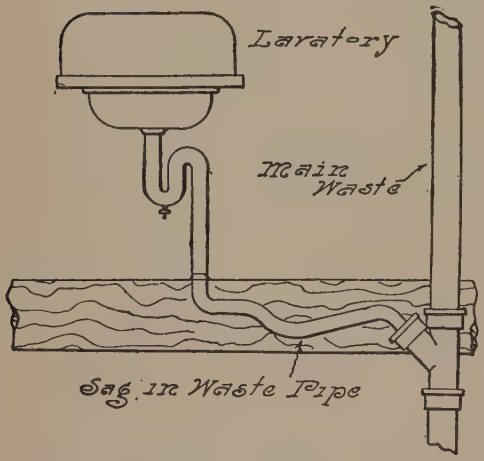


FIG. 117.—Double-Trapping Produced by Sagging of Waste Pipe.

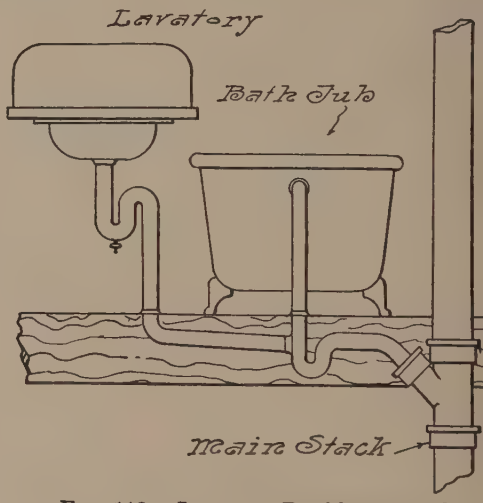


FIG. 118.—Lavatory Double-Trapped.

instance, may be provided with every luxury in the form of high-grade fixtures and brass work and trimmings, and apparently be all that could possibly be asked for, and at the same time the piping under the floor and in the partitions may be of the most unsanitary character and of the poorest workmanship.

In Fig. 117, for instance, the sagging of the lead waste results in double-trapping the fixture, which is always a serious matter. In the running of long lines of lead waste, the proper supporting

of the pipe is a matter of much importance, and a matter which is often sadly neglected. Another instance of the double-trapping of a fixture is to be noted in Fig. 118. The latter does not come

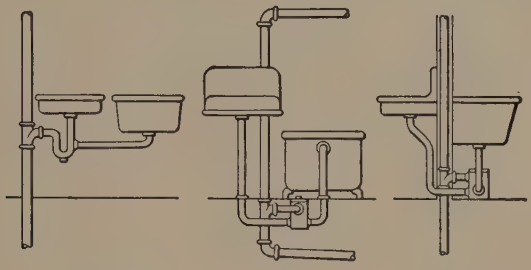


FIG. 119. FIG. 120. FIG. 121.

FIG. 119.—Kitchen Sink and Wash Trays Served by One Trap.—Poor Practice.
FIG. 120.—Lavatory and Bath Tub Connected into Drum Trap.—Poor Practice.
FIG. 121.—Sink and Wash Trays Connected into Drum Trap.—Poor Practice.

so much from carelessness as it does from ignorance on the part of the workman, or from an attempt to complete the work with the least possible expense to the plumber. These glaring errors, however, are very much less in evidence in sections that come under

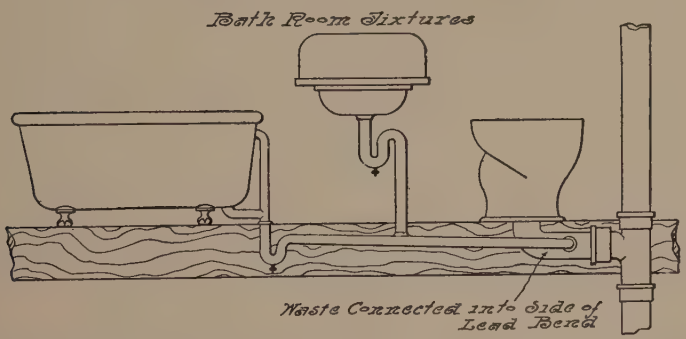


FIG. 122.—One Waste Entrance only for the Three Bath Room Fixtures.

the plumbing inspector's control than in the smaller towns that are not thus favored.

Many of the most objectionable features connected with the installation of fixture wastes, however, come from the neglect to provide proper facilities for carrying the waste away, rather than

from work that is installed with such errors as those shown above. It is a very common practice, for instance, to serve two fixtures by one trap, as in Figs. 119, 120, and 121. This practice arises

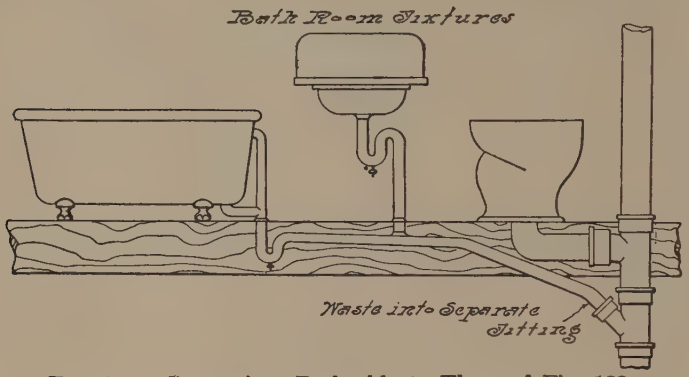


FIG. 123.—Connections Preferable to Those of Fig. 122.

most often in the case of the kitchen sink and wash trays, and in the case of lavatory and bath tub, and is a practice that is followed in a great many cities having plumbing ordinances which require a separate trap under each fixture. Briefly stated, the principle

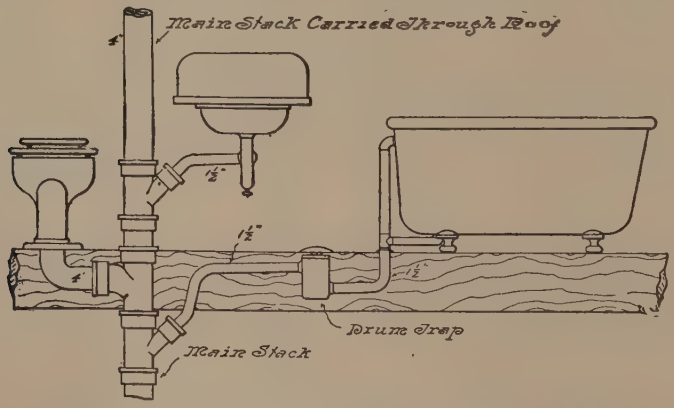


FIG. 124.—Separate Waste Entrance for Each Fixture.

involved is, that as far as possible, each fixture should be separately trapped, and have a separate entrance into the drainage system, and the consideration of the latter is the chief feature of this chapter. It may, perhaps, be considered to best advantage in the

case of bath room connections. The work shown in Fig. 122, in which the wastes from all three fixtures of the bath room are provided with but one entrance into the drainage system, is very often

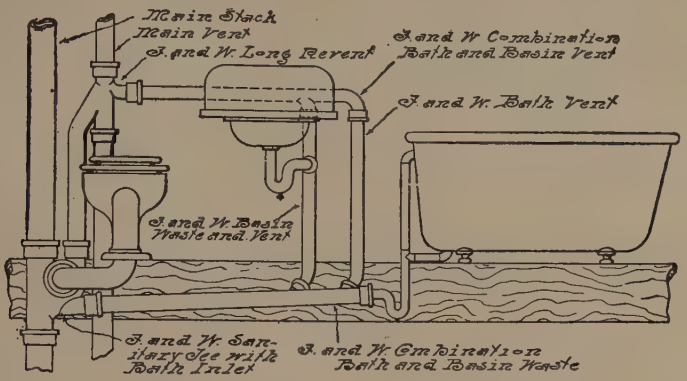

Main Stack
Main Vent
S. and W. Long Revent
S. and W. Combination Bath and Basin Vent
S. and W. Bath Vent
S. and W. Basin Waste and Vent
S. and W. Sanitary Tee with Bath Inlet
S. and W. Combination Bath and Basin Waste

FIG. 125.—Separate Waste Entrances by Means of Special Fittings.

to be seen even in cities which pride themselves on their high standard of plumbing. It cannot be denied, however, that this is very poor work. Fig. 123 shows an improvement in providing a second entrance for the bath and lavatory. This would in general,

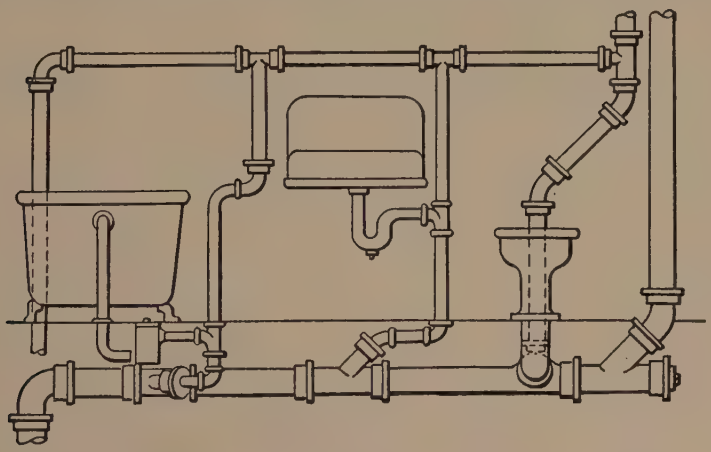


FIG. 126.—Separate Waste Entrances. Use of Special Fittings.

no doubt pass muster as a fairly good piece of work, but it cannot be compared with the work of Fig. 124, in which each fixture is provided with its own separate entrance into the drainage system.

Fig. 124 certainly represents the most sanitary and workmanlike arrangement of waste connections. In such work a stoppage on either waste affects that fixture alone, and has no influence on the working of any other fixture, while in the other work mentioned a single stoppage at certain points is able to prevent the use of two, or even all three, fixtures.

The special fittings which have recently appeared on the market in such numbers and in such variety of form are of the greatest aid in obtaining separate waste entrance for fixtures, but in addition provide means of obtaining continuous vents. Two examples of the use of special fittings are to be seen in Figs. 125 and 126, and at various other points in this work other similar instances may be noted.

CHAPTER XV

WATER-CLOSETS

The water-closet, without doubt, has received more earnest attention in its development than any other plumbing fixture or device. Its use has also had more influence in the working out of the details of the present sanitary system than any other feature that is connected with plumbing construction. It is not the pur-

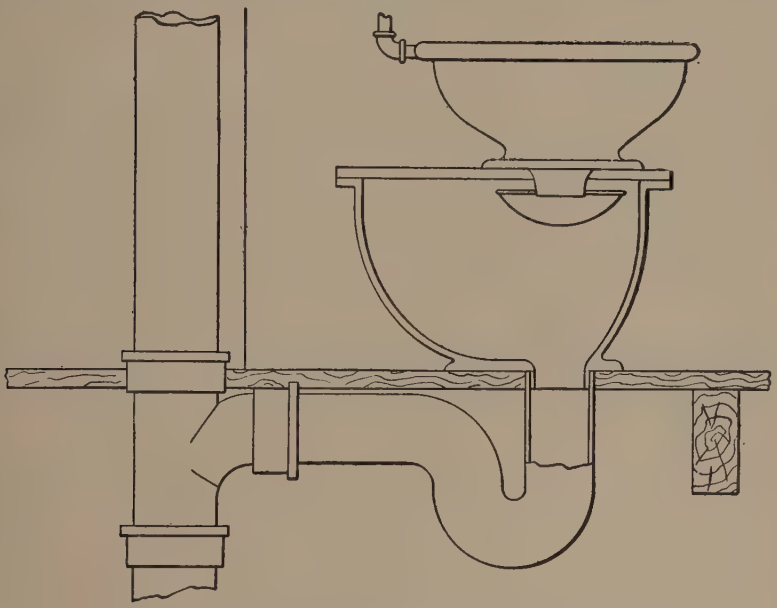


Fig. 127.—The Pan Water-Closet and Its Connections.

pose of this work to enter into the historical features of the development of plumbing, and therefore simply passing mention will be made of the old-time styles of water-closets, in order that comparison may be made between the present fixtures of sanitary construction and the old-time fixtures with their numerous sanitary defects.

The pan closet, shown in Fig. 127, was for a long time uni-

versally used on good work and was considered as a most efficient fixture. This fixture was developed in the natural course of the evolution of the water-closet, but in our knowledge of to-day it is difficult to conceive of a more filthy arrangement. Its use is now everywhere prohibited, although even now found to some extent in some sections on old work.

As shown in Fig. 127, the pan closet consists chiefly of the bowl, the receiver for the waste, the pan and a system of levers for operating the pan.

The waste entering the fixture, fell into this pan, which was

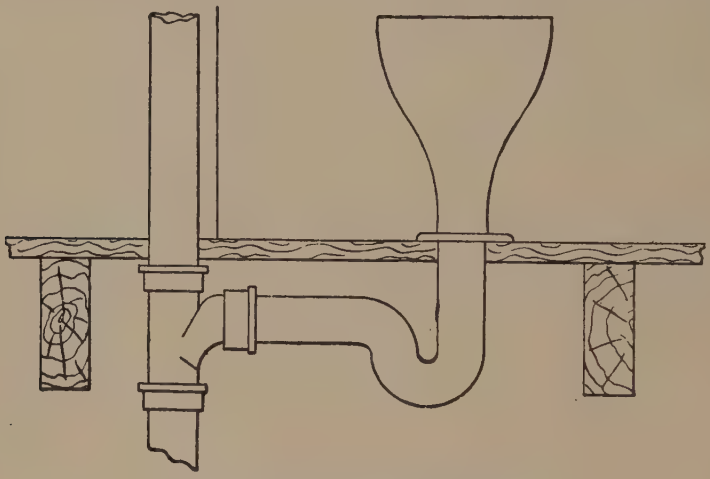


Fig. 128.—The Long Hopper Closet.

of copper, and contained enough water to make a seal over the lower end of the bowl. The system of levers was used to upset the pan and throw its contents into the receiver. The latter soon became covered with filth and the pan also became corroded and filthy. Beneath the pan closet the S trap added to the general filthiness of the fixture. The unsanitary features of the pan closet, as may well be seen, were of such an extent that they cannot easily be exaggerated.

Following the pan closet came the valve and plunger closets, showing an improvement in several points over the first-named fixture. These closets, in their day, were looked upon as perfect

fixtures, although from our present standpoint they appear filthy and unsatisfactory in the extreme.

The long hopper closet, shown in Fig. 128, was another type of water-closet formerly in extensive use. This form of water-closet depended for its trap upon the S trap located below it, as shown in the illustration referred to. These traps were either of lead or cast-iron. Very often in old-time bath-room work this trap was the only one in the room, all other fixture wastes being connected into it and depending upon it for their trap seals. It will readily be

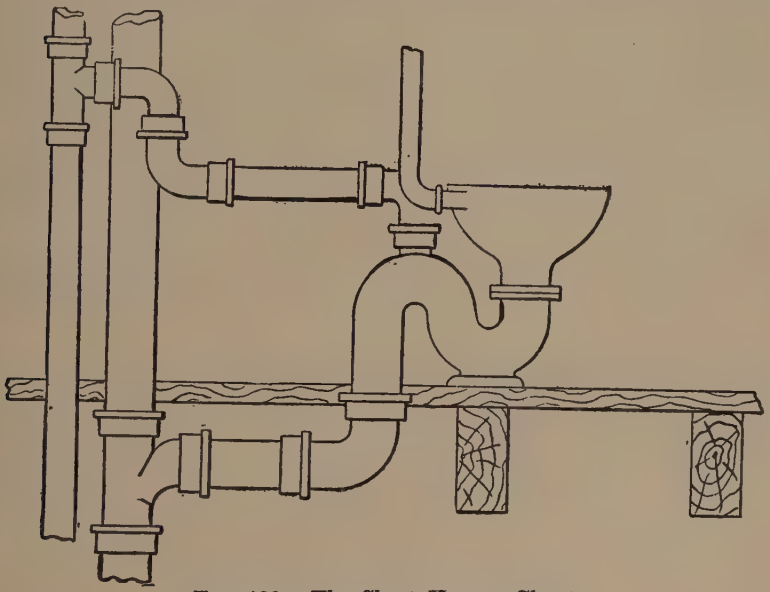


Fig. 129.—The Short Hopper Closet.

seen that such work, without venting of any description, was very far from being comparable to the sanitary work of to-day. The short hopper closet of Fig. 129 is still another form of water-closet of the earlier type, somewhat better than its predecessors, and even now somewhat in use on poor work, but still full of defects, as the water-closet is now understood.

The old-style water-closets, then, were full of defects of all kinds. Some of the features which were objectionable in these fixtures are the following: They had large surfaces, both on the earthenware itself and on the mechanical parts, which were either

entirely dry or insufficiently flushed, and therefore presenting opportunity for the collection of filth. Mechanical devices, such as many of them had, are in themselves objectionable. Many of the earlier forms of water-closets were without flushing rims and the devices used for spreading the flush over the surface were entirely inadequate to their purpose.

The old-style fixtures presented dead ends that were unsupplied with water and ventilation; the flush provided was insufficient and not properly applied; the trap, not being a part of the fixture itself, necessitated the use of a special trap, which added greatly to the fouling surface, etc. Many other objectionable features might be named, to show that the old-style forms of water-closet were very filthy affairs, giving out dangerous odors and gases, and at all times constituting a serious menace to the health of the inmates. However, as in everything else, these fixtures continually grew in excellence as the process of evolution went on, and the present sanitary and perfect operating water-closet would not be possible if it had not been for the earlier attempts and the constant effort to reduce their imperfections.

Some of the features which the water-closet should possess, and which the better types of to-day do possess to a large degree, are the following. The fixture should have a trap, with a liberal seal, the trap forming a part of the fixture, in order to reduce the exposed surface, and to increase its efficiency in other ways; all surfaces exposed to soil should be thoroughly scoured by the flush; the flush should be abundant for its purpose, without undue waste of water; the flush should be strong, but noiseless as possible; the trap seal should be open to view; no mechanical devices should be used in the water-closet bowl; and all waste entering the fixture should be quickly and completely removed. The water-closet should be made as compact and of as simple shape as possible, and so formed as to prevent spattering and to allow soil entering it to fall into the trap rather than upon an exposed surface. It is necessary to construct the fixture of strong material, as it is often subject to rough usage; its surfaces should be smooth, both inside and outside; and the glazing should be such that it will not craze. The glazing of water-closets, until within recent years, was liable to crack or craze, thus allowing moisture and filth to be absorbed by

the fixture, making of it a most unsanitary device. As known to the reader, the water-closet of to-day, as well as other fixtures, are open, free from the boxing or sheathing that surrounded each fixture of the old-time plumbing system. The open fixture is far more sanitary than the sheathed fixture. The latter not only presents corners and joints which become filled with filth, even under the best of care, but the sheathing incloses an unventilated space, these two features acting to maintain in the room in which the fixtures are located, a less pure atmosphere than is to be found when the fixtures are open.

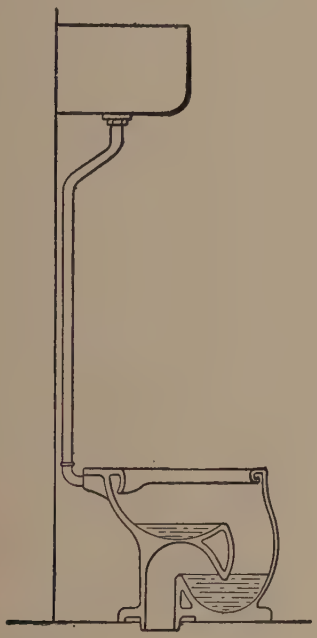


Fig. 130.—The Washout Water-Closet.

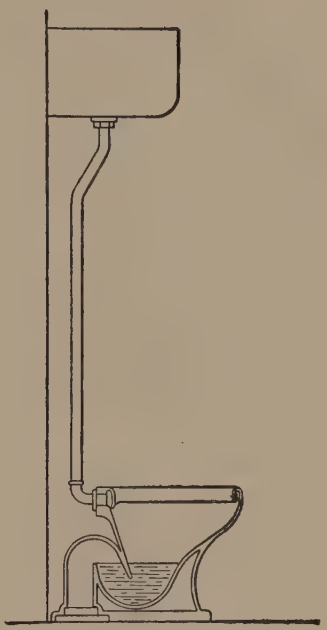


Fig. 131.—The Washdown Water-Closet.

Following the types of water-closets mentioned above came the washout water-closet, which is in extensive use to-day, in some sections of the country. This fixture is shown in Fig. 130 and was a very great improvement over previous forms of water-closets. As compared with more recent types, however, the washout water-closet is seen to have certain serious defects. As seen in the illus-

tration, this fixture has a flushing rim, a trap within itself, and a pool of water directly below the seal. The soil falling into this pool is removed by the force of the flush, the greater part of which is directed to this point. While there is no difficulty in removing the soil from the pool, in so doing the force of the flush, owing to the work of removing the soil, and to the construction of the fixture, is used up by the time it reaches the trap. Therefore the flush has not sufficient strength to remove the contents of the trap with force, the result being that the waste from this part of the fixture is carried off more by overflow than by any other stronger force. In the washout water-closet the depth of water in the pool is not sufficient to submerge the soil, a point in which certain other water-closets are not lacking. Other defects in this form of fixture are that it has a large amount of fouling surface, and that it is noisy, the latter objection being due to the falling of the water from the pool into the trap.

The washdown water-closet, shown in Fig. 131, though appearing earlier than the washout, is superior to the latter in several ways. In the washdown closet the soil falls directly into the trap. Therefore the flush acts more directly and more strongly in removing waste from the fixture than in the washout, in which, as just observed, the soil must first be forced from the pool into the trap before being carried out of the trap. The washdown water-closet is provided with flushing rim and presents a smaller amount of fouling surface than the washout.

Although the washout and washdown fixtures were great improvements over other water-closets that had been brought out, it remained for the principle of siphonage to be applied to the action of the water-closet to make possible the high-class fixtures of the present day. The application of this principle has, indeed, resulted in a fixture of such perfect action and of such sanitary excellence that it is difficult to see how the fixture can be further improved.

In Fig. 132 is shown a sectional view of the siphon-washdown water-closet, the action of which is the following: The construction of the fixture provides a horizontal leg on the outlet of the fixture, which is somewhat contracted in area as compared with the vertical part of the outlet. When the waste of the fixture, in

flushing, reaches the contracted horizontal leg, its passage is retarded to a considerable extent, which allows the entire outlet passage between the trap and the horizontal leg to completely fill with water. This solid plug of water, in passing off, creates a vacuum, and results in establishing the action of siphonage. This

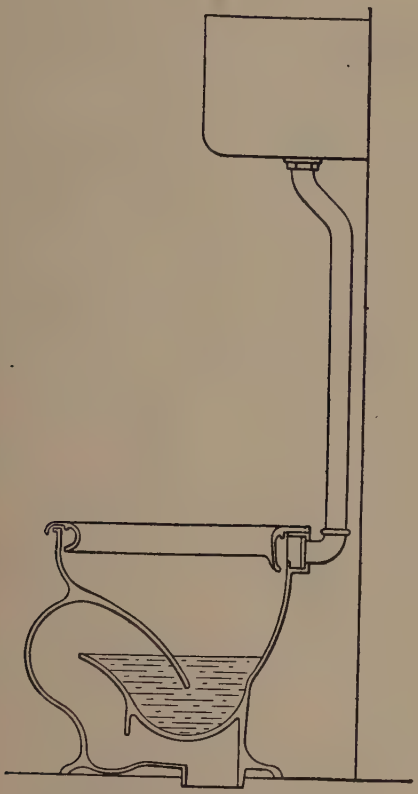


Fig. 132.—The Siphon Washdown Water-Closet

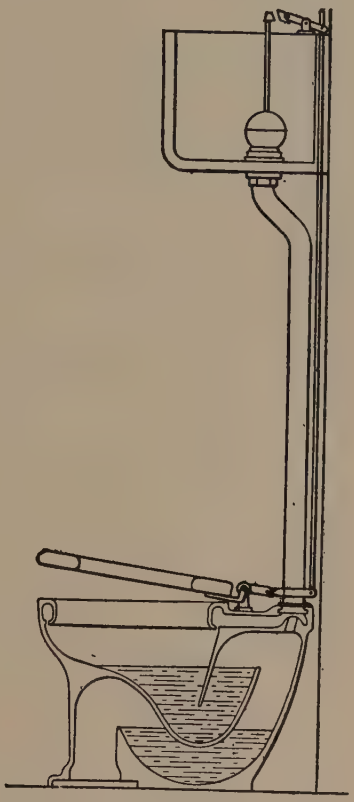


Fig. 133.—The Siphon Water-Closet.

action is very strong, and quickly and forcibly pulls the entire contents of the trap out and into the drainage system. After the siphon breaks enough water enters the fixture to form the trap seal. Two or three flushes of the siphon water-closet may usually be obtained if desired, by allowing the supply to fill the flush tank to a higher level. After the first siphonic action breaks, the in-

coming flush quickly fills the outlet of the fixture a second time, and when the right conditions are reached, the fixture again siphons. The scouring action of this fixture, both within itself and on the connections into the drainage system, is far superior, it is clear to see, to that of any of the fixtures previously considered.

Another form of siphon water-closet is to be seen in Fig. 133. This type has two traps, one above the other. The second trap is not provided as a means of protection against the entrance of sewer air, but to aid in the formation of the siphon. As the flush enters the fixture from the flush tank, it divides, one half going through the flushing rim, scouring the bowl, and aiding in discharging the contents of the fixture. The other half of the flush passes through the passage shown in the illustration, directly into the lower trap. This jet forces the air between the two traps through the water of the lower trap, thus producing a partial vacuum, and forming a siphon, which rapidly draws out the contents of the fixture. This division of the flush not only siphons the fixture, but obviates the spattering which occurs in water-closets when the entire flush is thrown directly into the bowl, and at the same time, a more energetic passage of water through the lower trap is secured, which entirely prevents the possibility of anything remaining in the trap after the siphon has operated. Another good feature of this type of water-closet is that it is comparatively noiseless.

In addition to showing the features of this special type of fixture, Fig. 133 also shows apparatus for automatically starting the flush tank. The ordinary method is by means of the chain and pull, but in public toilet rooms, where it is often desirable not to depend on the individual using the fixture to flush it, the flush tank may be operated by the releasing of the water-closet seat. As will be seen from the illustration, this is accomplished by levers which operate a rod which in turn acts on the flush valve.

In Fig. 134 is shown another form of water-closet, known as the siphon-jet type, which represents the most perfect water-closet which has yet been devised.

The action of this fixture is the result not only of a contracted horizontal outlet leg, but also of a special jet or passage, which

throws a strong stream or jet of water directly up into the rising arm of the trap. The jet is formed by a passage cast on the outside of the bowl, communicating with the point at which the flush enters the fixture, and delivering the jet through the opening at the bottom of the trap. This jet aids the flush that enters the bowl through the flushing rim, in quickly filling the outlet leg, and in producing the necessary vacuum, upon which the action of the siphon water-closet depends. This type of water-closet is exceed-

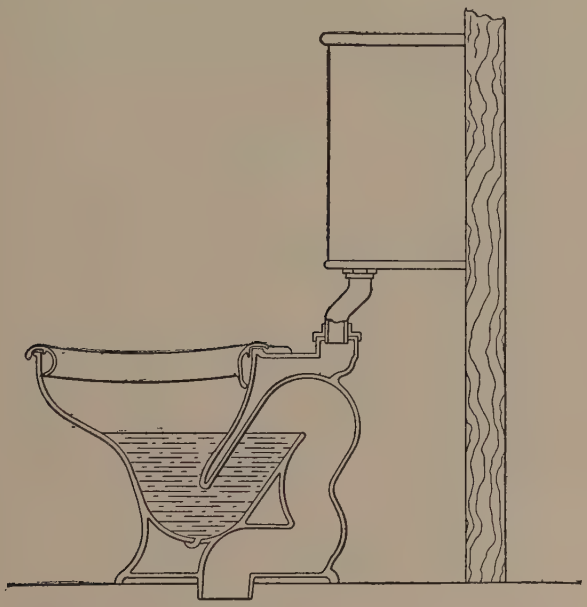


Fig. 134.—The Siphon-Jet, Low-Down Water-Closet.

ingly strong in its action, and as already stated, represents the most advanced type now in use.

The siphon water-closets, then, show the following desirable features: Their action results in the rapid withdrawal of the entire contents of the fixture, which is comparatively noiseless; the scouring action is very strong; there are no unflushed surfaces; there is no waste of energy as seen in the wash-out type; all soil entering the bowl is submerged, and the fixture is very compact and graceful in design.

In Fig. 134 the flush tank shown is of the low-down pattern.

This style of tank has now come into very extensive use, until at the present time it has almost entirely superseded the high tank in many sections of the country.

The low-down tank is no more efficient than the high tank, but to many its appearance is more tasteful than the high tank. The low-down tank combination is more compact, and may be used in many places where it is difficult or impossible to obtain the necessary elevation for the high tank. The low-down tank is also more accessible in case of repairs than the high tank, which

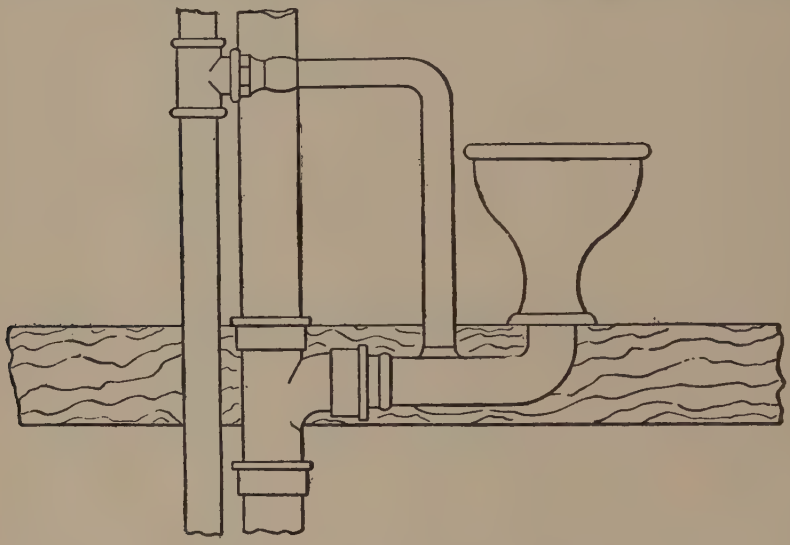


Fig. 135.—Connections for Water-Closet.

must often be taken down in order that the working parts may be gotten at.

The high tank generally delivers its flush through a $1\frac{1}{4}$-inch pipe, its ability to throw a large volume of water into the fixture quickly, depending upon the elevation of the tank. The absence of elevation of the low-down tank is surmounted by providing a connection of larger size between the tank and water-closet. This connection is usually 2 inches in diameter, which is of sufficient size to throw enough water into the bowl to make its action entirely satisfactory.

Whenever the low-down tank is used, it is necessary to use in

connection with it, a water-closet of the siphon type, as satisfactory results cannot be obtained from the use of water-closets of less positive action.

Owing to the nature of its construction, the water-closet must be connected to the drainage system in a different manner than other fixtures.

Fig. 135 will show the manner in which these connections are generally made, when the drainage pipes are of cast iron. As shown, the connection is made by means of a lead bend con-

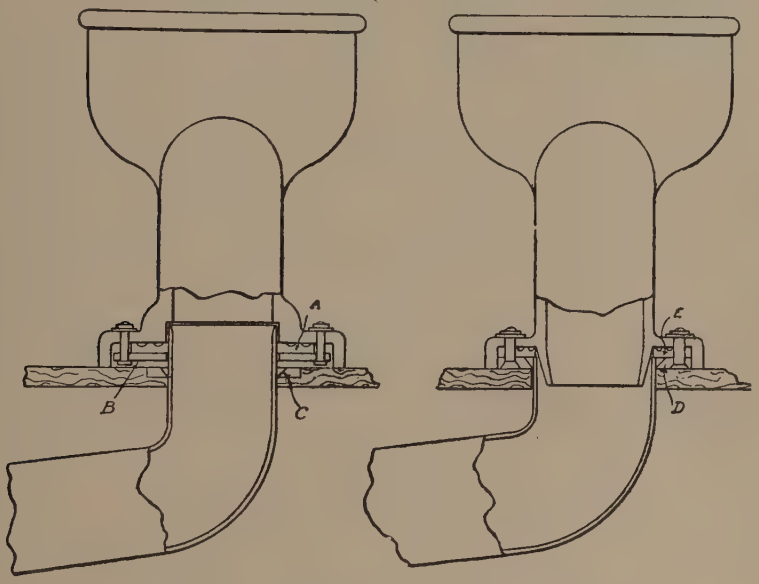


Fig. 136.—Water-Closet Floor Connections.

necting to the outlet of the water-closet. The lead bend is wiped to a 4-inch brass ferrule, and the latter calked into the cast-iron fitting. The vent is generally taken from the lead bend, the proper point of connection being on the upper part of the horizontal section of the bend.

The lead bend and water-closet may be connected in several ways. The simplest and least satisfactory method is by means of the putty joint, the top of the lead bend being flanged over onto the floor, after which a ring of putty is laid on top, and the base of the water-closet screwed down onto the putty. The putty

spreads and forms a joint between the lead bend and the water-closet. The objections to this method are, that if the fixture receives a blow, or the floor settles, the joint cracks, allowing a leakage of water around the base of the fixture. The oil of the putty works into the flooring and discolors it.

In Fig. 136 are shown types of floor connections, which it will readily be seen, are far superior to the putty connection. In the method shown at the right, the lead bend is brought up above the floor a short distance, and to it the brass floor flange D is soldered. On the flange, the rubber gasket E is placed, the bolts inserted, and the fixture set in position, after which the nuts are screwed onto the bolts, and the latter made tight. This draws the rubber gasket up against the base of the water-closet, making a gas-tight and water-tight joint.

In making the floor connection seen at the left in Fig. 136, the floor is cut to receive the flange C, which is soldered to the lead bend, the exposed upper edge of which should be smoothed, in order that there may be no rough places on which substances in the waste may catch. The upper part of the lead bend may be painted with white lead to which the edges of the rubber gasket will strongly adhere. The flange B is then dropped into place, the rubber gasket forced on, the bolts put in, the closet set in position, and the bolts drawn up. The flange C takes the weight of the lead bend, thus taking all strain off the base of the closet. The flange B being loose, accommodates itself to any unevenness in the setting of the bowl. In these last two respects, the connection last named is superior to the first named.

The floor connections described are for use only when the cast-iron drainage system is employed. Other methods must be employed when the Durham system is in use. The connections of the water-closet in use on the Durham system are shown in Fig. 137, from which it will be seen that no lead is used in the work. The floor connection is made by means of a brass floor flange, screwing into the iron bend. This floor flange is shown in separate detail in Fig. 137.

In roughing-in the connections for the water-closet, the vertical part of the bend should pass through the floor so that the center will be right to receive the outlet of the fixture. To accomplish

this, it is necessary to know the water-closet that is to be used, in order to know how far out the outlet will come. To find the center of the outlet of a water-closet that is in position, be governed by the screw holes on the side of the base. When there is one screw hole on each side of the base, the center of the outlet will usually be opposite these holes. When two holes appear on each side, the center will generally be found midway between them.

After the bend is in position on roughing work, a circular disk of sheet lead should be cut out and soldered into the end of the bend, in order that it may be sealed against the entrance into it

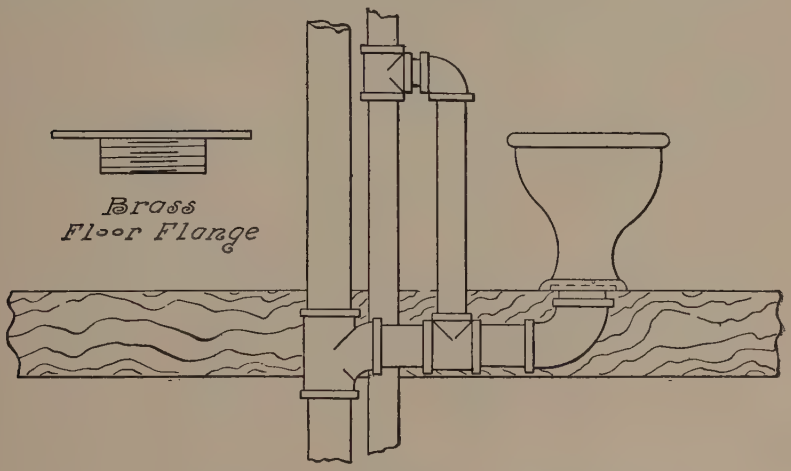


FIG. 137.—Connections of Water-Closet on the Durham System.

of refuse of any kind. If the bend projects through the floor far enough, the end may be mashed in and soldered across the top edge.

In a large majority of cases, the water-closet connection is made into a T-Y fitting, as shown in Fig. 135. It is better to make the connection into a Y fitting and bend, but in most work this is impossible, as such a connection takes up more space than can be allowed, and brings the fixture too far out into the room, as will appear from Fig. 149.

The use of the Y and bend provides the smoothest possible path for the waste, but on vertical stacks, the use of the T-Y is not considered poor practice. It should never be used on hori-

zontal work, however. It often happens in the installation of lines of water-closets in factories, schools, and similar buildings, that the Y and bend can be used to advantage, as shown in Fig. 138.

In this work, the vent for each fixture is taken off the short piece of lead pipe, which is used instead of the lead bend. The work shown in Fig. 138 is especially practicable when the building construction and the purposes of the building are such that it is not undesirable to run the horizontal line of soil pipe on the ceiling of the floor below the line of fixtures.

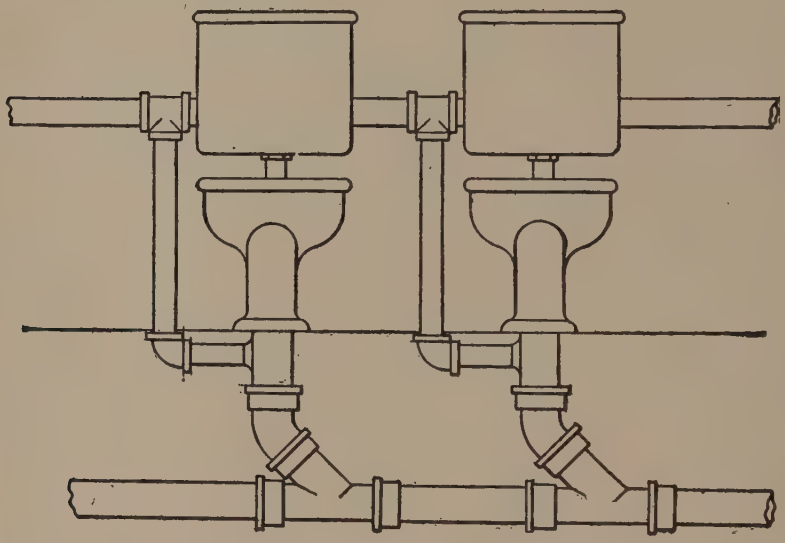


Fig. 138.—Connections for Line of Water-Closets.

If the work cannot be installed as in Fig. 138, the Ys may be used so that their branches point horizontally, in which case a lead bend must be used in connecting each fixture.

In other instances it is desirable to run the horizontal line above the floor. This method necessitates the use of a special form of fixture with its outlet above the floor. If the line of soil pipe is to be exposed to view, it may be supported on special pipe-supporting fittings. These fittings are made to adjust to any pitch at which it is desired to run the pipe. Work of this description may be seen in Fig. 139.

The principles of the venting of water-closets are taken up under the chapter on venting, from which it will be seen that the

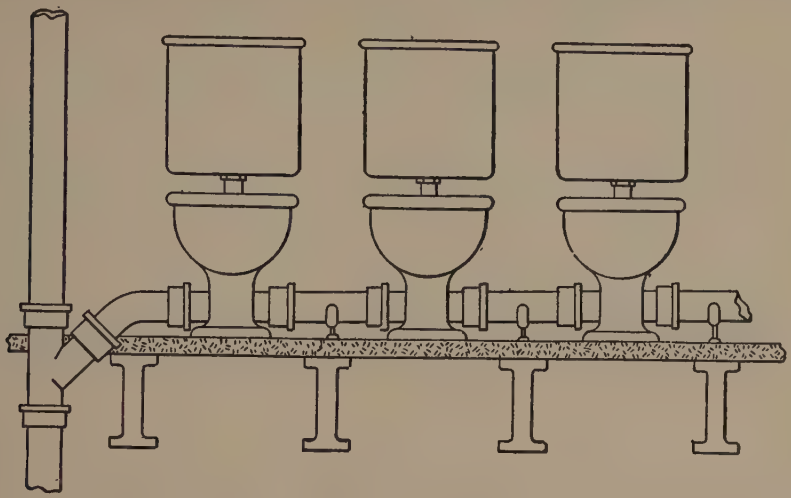


FIG. 139.—Soil Pipe for Line of Water-Closets Supported by Supporting Fittings.

common method consists in taking it off the lead bend, as in Fig. 141. The venting of water-closets from the bowl itself, as in Fig.

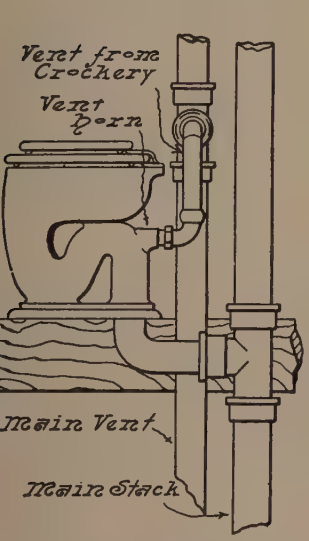


FIG. 140.—Water-Closet Vented from the Bowl.

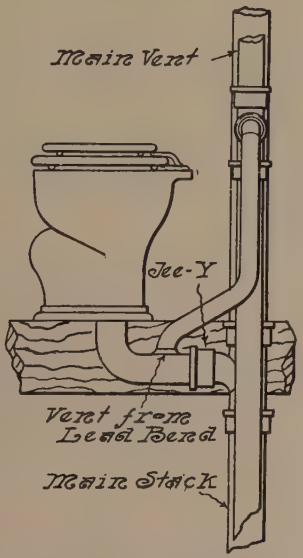


FIG. 141.—Ordinary Method of Venting Water-Closets.

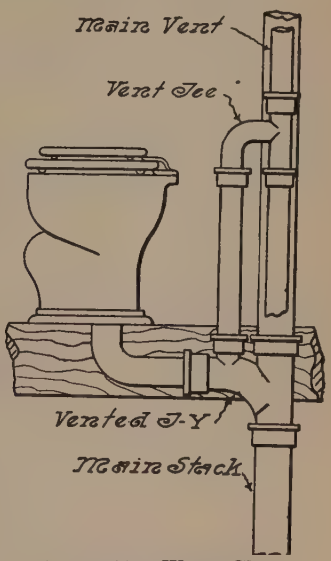


FIG. 142.—Water-Closet Vented from T-Y.

140, is no longer considered good practice. In addition to the regular method of venting, special waste fittings provided with vent openings are now much used, one of the simplest of these appearing in Fig. 142.

Several of these fittings are to be seen in Figs. 143 to 146. The fitting of Fig. 143 is a common stock fitting, known as the vented T-Y. This fitting is an excellent one, and where practicable to use it, the work may be made very rigid and substantial, and the labor called for is considerably less than in venting from the lead bend in the usual manner. The chief objection to its use is that it brings the water-closet farther out into the room than is desirable, in many cases. Fig. 144 shows a fitting constructed on the same general principles as the vented T-Y, but with the hub, to which the lead bend is connected, much closer to the wall. This advantage is secured by constructing the waste entrance in such a way that it enters the main body of the fitting spirally, on the side. These fittings may be secured with the hub on either the right or left hand. The vent is taken off the fitting in a manner similar to that of Fig. 143.

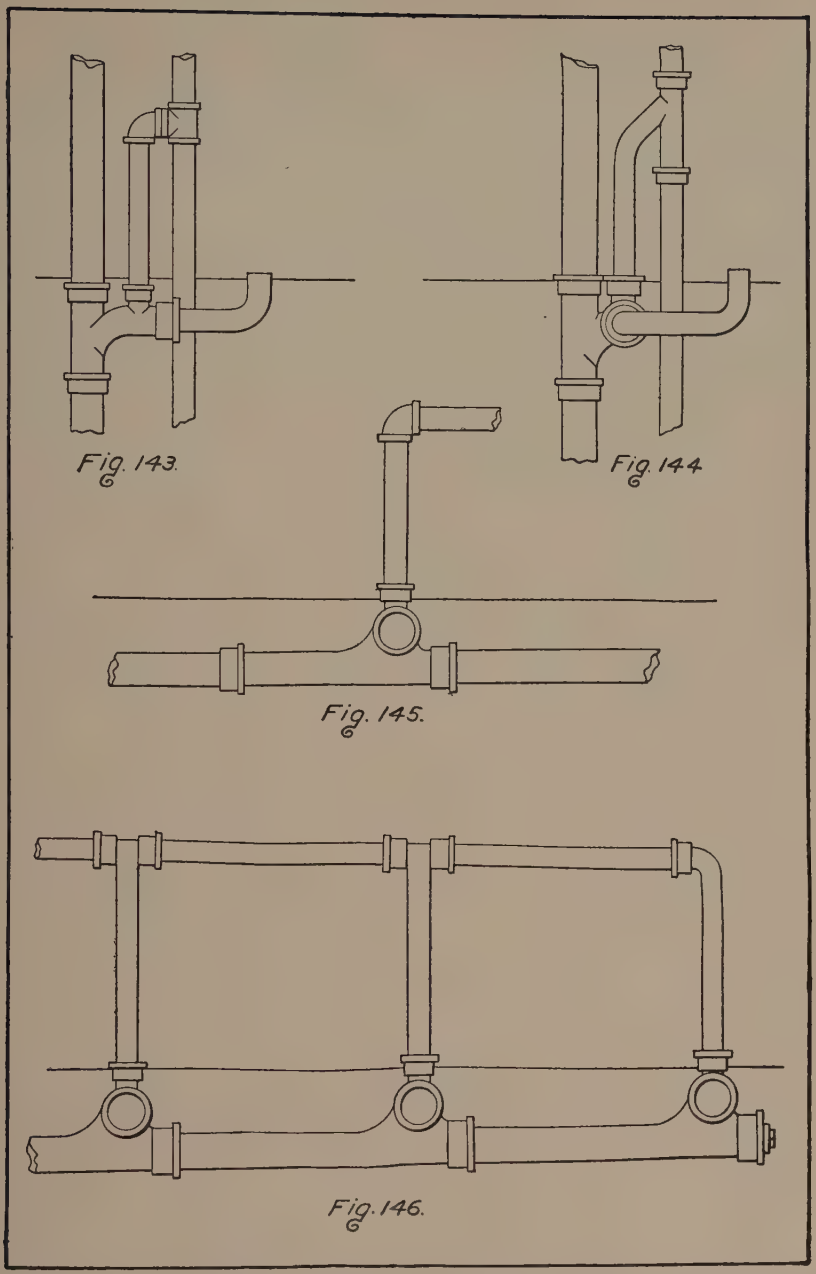
Fig. 144 also shows the use of a special revent fitting, which has an offset, allowing a connection between the vent hub of the waste fitting and the main vent line. It will readily be seen that the use of these two fittings effects a great saving in labor in the construction.

In Fig. 145 is shown a fitting of different character, for use on horizontal lines of soil pipe, whereas those shown in Figs. 143 and 144 are for vertical lines.

If this fitting is used for the lowest water-closet on the system, the main vent line may often be connected into its vent opening, answering at the same time as the vent for the water-closet itself.

Fig. 146 shows the same fitting as in Fig. 145, used on a horizontal line of soil pipe serving several water-closets. The waste openings of these fittings, it will be observed, point out in such a direction that lead bends must be used in making the connections. The vents from these fittings may be constructed of ordinary pipe and fittings, as in Fig. 145, or with special revent fittings, as shown in Fig. 146.

Figs. 147, 148, and 149 show excellent methods of wasting and



Figs. 143–146.— The Use of Special Water-Closet Waste and Vent Fittings.

venting water-closets by means of special fittings. The method of Fig. 147, in which the temple vent fitting is used, is probably the least common of the three, but is nevertheless to be considered a specially good one, and there would appear to be little reason for its limited use.

It often happens, especially in tenement and apartment houses, that water-closets on the several floors, back up to each other on opposite sides of a partition. Under such conditions, a good method of wasting and venting is seen in Fig. 150, by the use of a vented double T-Y. An improvement on this method, however, is that of Fig. 151, in which a special fitting known as a sanitary cross with double vent is made use of, in connection with the double revent fitting shown.

It will be noticed that while the use of these special fittings must necessarily save a considerable amount of labor as compared with ordinary methods, other advantages are also gained. They often make the drainage and vent piping and their connections much more compact, and reduce the number of joints greatly. The latter is a feature of importance, as the smaller the number of joints there are on any plumbing system, the less liability there will be of defects and of stoppages.

Other special water-closet waste and vent fittings of much value are to be seen in Figs. 152 to 155.

The fitting A in Fig. 152 is a double T-Y with double vents. When this fitting is made use of, the double vent fitting shown will be found of more advantage than vents of pipe and ordinary fittings. From the top of the double-vent fitting, a short revent fitting similar to that of Fig. 144 may be used, or the connection made with pipe and fittings. If the latter method is adopted, the reader will easily see that it cannot be accomplished, either with cast- or wrought-iron pipe, without the use of several more joints than appear in the work of Fig. 152. Another fitting, similar to A, is shown at B, it being provided with a single vent instead of a double vent.

It would appear that as efficient work may be accomplished with B as with A, as far as the venting of the two water-closets is concerned, and the number of fittings used with A and the labor necessary will certainly be greater than in the case of B. C shows

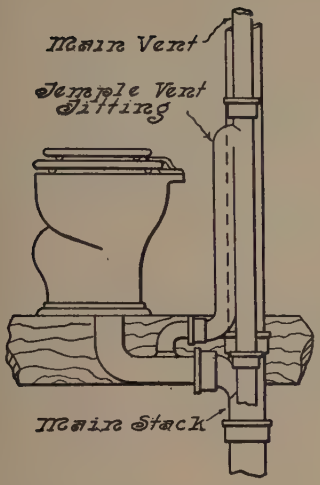


FIG. 147.—Water-Closet Vented into Temple Vent Fitting.

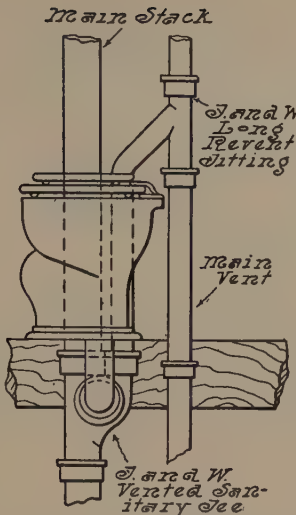


FIG. 148.—Use of Special Waste and Vent Fittings.

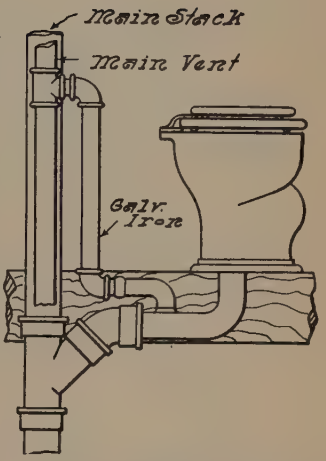


FIG. 149.—Venting of Water-Closet with Wrought Iron Pipe.

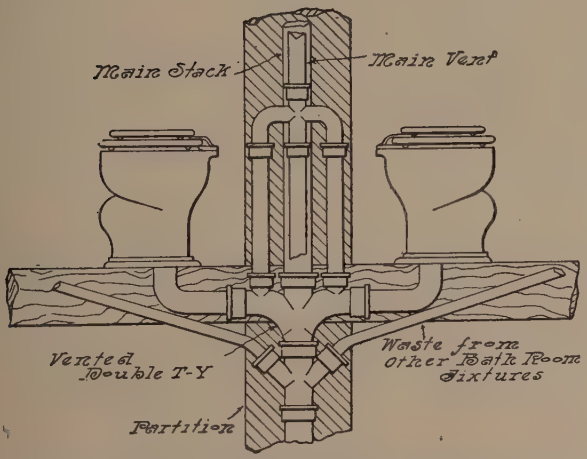


FIG. 150.—Waste and Vent for Water-Closets on Opposite Sides of Partition.

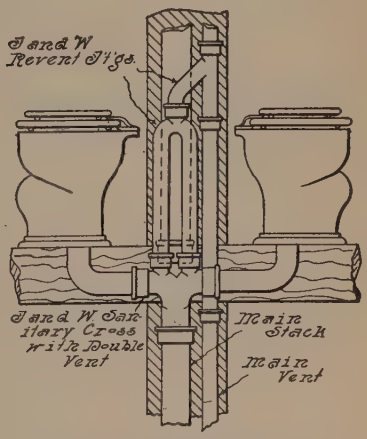


FIG. 151.—Use of Special Waste and Vent Fittings.

still another vented waste fitting, similar to that of Fig. 144, but with an extra inlet for the waste of another fixture. The revent fitting connected to the vent opening of the waste fitting, is also provided with an additional opening to receive the vent from the fixture entering the special waste inlet of the waste fitting. The revent fitting may be secured with the additional opening located as shown, or on either side of the fitting. If the bath waste enters the additional opening of the waste fitting, and its half-S trap is located within a short distance of the stack, the vent for the water-closet may act also as the vent for the bath trap. Fig. 153 shows a special offset fitting, D, for use in connection with the vented T-Y, when the latter is used to serve a water-closet on the lowest floor, or when no other fixtures enter the stack below the water-closet. This offset connects the vent stack into the soil stack as now generally required, and also serves as the vent for the water-closet.

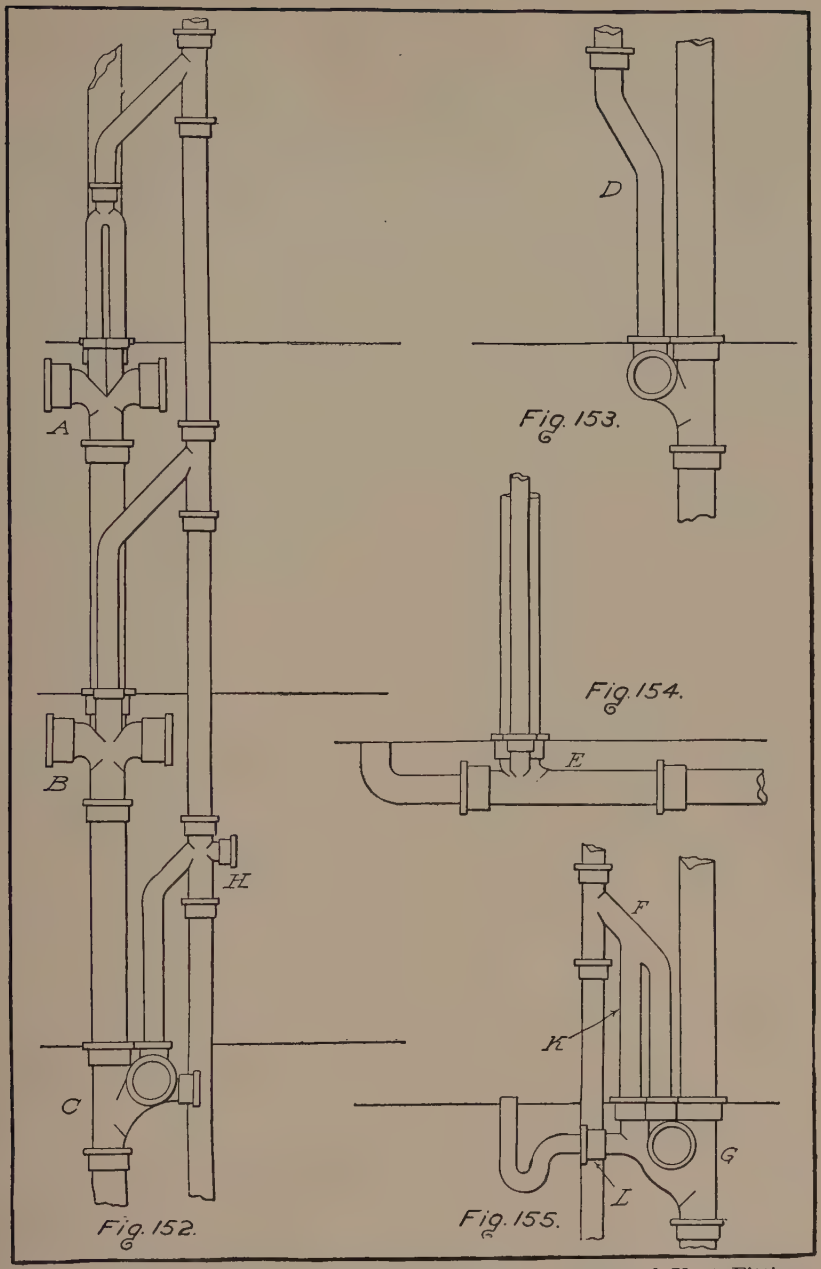
Fig. 154 illustrates the use of another vented fitting, E, for use in connection with a water-closet entering the end of a horizontal line of soil pipe. This fitting allows the entrance of the lead bend into the end and into its vent opening the water-closet vent may be connected to serve also as the main vent in many cases.

In Fig. 155 are illustrated a multiple waste and vent fitting, G, and a double revent fitting, F. The waste fitting is provided with two vent hubs, a waste opening for the water-closet and another for any other adjacent fixture. One of the vent hubs is to receive the vent for the water-closet, and the other the vent from the bath trap or other trap that is located below the floor.

The double revent fitting may be obtained in several modified patterns. For instance, another vent opening may be obtained at the top of the fitting, as shown in connection with the fitting H of Fig. 152.

The fitting may also be obtained with a waste opening at K. Such a waste could not be used, however, if the fitting were provided with the branch L, as this would mean that the same pipe served as both waste and vent, which is not right under any circumstances. A waste opening at K would provide a continuous vent with waste for a lavatory or sink.

All the special fittings shown in Figs. 143 to 146, and 152 to



FIGS. 152–155.—The Use of Special Water-Closet Waste and Vent Fittings.

155, with the exception of the vented T-Y of Fig. 143, are known as F and W combination vent, revent, and drainage fittings. They are of great practical value, and are coming into use to a considerable extent. As already indicated, they save a large amount of labor, reduce the number of joints, and make the work compact.

Their use also allows continuous vents to be obtained under almost all conditions. It may be stated that these fittings constitute only a small part of the full line of such special fittings. Others, for use in connection with other fixtures than water-closets, will be seen elsewhere.

Owing to the nature of the waste which the water-closet receives, it should be surrounded with the best possible sanitary conditions. This is especially true, also, of the urinal. With our present knowledge and appliances, however, it is not now so difficult to install these fixtures under difficult conditions and still obtain good results, as it once was.

The water-closet should never be installed in a dark or unventilated place, for light and ventilation are absolutely necessary if this fixture is to be kept from becoming a foul nuisance. When properly provided for in these two respects, however, this fixture need prove scarcely more obnoxious than any other fixture. That this is true, is evidenced by the fact that the atmosphere of the modern well-lighted, well-ventilated bath room, provided with first-class fixtures and a properly constructed sanitary system, is scarcely more tainted than the atmosphere of the remaining rooms of the house.

The location of water-closets in cellars is always poor practice, though quite common in some sections. Whenever thus located, the water-closet compartment should be built with one of the cellar windows opening into it, in order that ventilation and light may be obtained as far as is possible under the conditions.

Whenever possible, the lighting of any room or compartment containing a water-closet or any other plumbing fixture, should be direct, rather than by means of light shafts. Exterior lighting, by means of which the benefit of sunlight may be obtained, is very desirable, as the action of sunlight is especially destructive to filth or germ life.

The natural ventilation of rooms through windows and doors is greater than commonly supposed, but when the water-closet is installed in any room, artificial ventilation is generally needed to keep the atmosphere of the room sufficiently pure. This matter is taken up in the chapter on local venting.

Considerable space has been devoted in this chapter to the venting of water-closets. A few additional remarks on the subject may be of value.

The water-closet is a more difficult fixture to siphon than any other to be found on the plumbing system. It is nevertheless true, however, that it may be siphoned. In a majority of cases, the water-closet trap is siphoned gradually, a few drops at a time, rather than completely at one such operation.

It is undoubtedly true that the venting of water-closets is sometimes demanded under conditions which actually make such provision unnecessary. For instance, when the water-closet is located close to its soil stack, on the top floor, it would be impossible in a plumbing system provided as the modern system is, with roof ventilation, to bring to bear upon its trap seal sufficient siphonic influence to produce even the smallest amount of siphonic action. Many other instances might be noted of water-closets located close to soil stacks in small plumbing systems, where it is really unnecessary to vent them. A water-closet located close to the foot of a stack serving a number of fixtures, or when located on a horizontal line, or when set at a distance from its stack, should always be vented, as siphonic influence on its trap seal under each of these conditions is sufficiently great to make its use necessary.

There are certain practices in connection with water-closet work which should not be followed, and which are of sufficient importance to demand special remark. It is a very common practice to connect the waste from other fixtures into the lead bend of the water-closet, rather than to provide a separate entrance into the stack for these fixtures. There is often a temptation to perform the work in this manner, as it certainly can be done at much less cost, and as it is sometimes difficult to do the work in the proper manner. Nevertheless, the practice is a poor one, for several reasons. In the first place, if the waste is thus connected, a stoppage in the lead bend will not only prevent the use of the water-closet

itself, but also of any other fixture whose waste is connected into the bend.

The wiping of a waste into the lead bend cannot usually be accomplished without the forming of spines of solder reaching inside the bend, which will inevitably catch lint and paper and other materials entering the water-closet.

If, however, the waste of another fixture must be connected into the lead bend, it should never be connected into the heel of the bend, as shown in Fig. 156, or into the upright section. It should be connected into the horizontal part of the bend, and as high up on its circumference as possible.

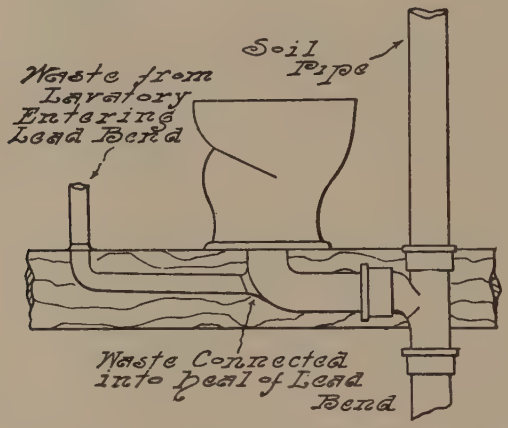


Fig. 156.—Waste Connected into Heel of Lead Bend.

The connection of the vent to the water-closet bowl has been mentioned elsewhere as a poor practice.

The use of offset water-closets is a practice more or less common, but now generally prohibited by plumbing ordinances. This form of water-closet bowl has no trap, but its shape is such that the uninformed person would not generally detect the fact. It is generally used to replace one of the old-time styles of water-closets which depended upon a lead or iron trap below the floor.

Instead of tearing out both closet and trap, the latter is often allowed to remain, and the fixture replaced by an offset bowl, as in Fig. 157. The objections to this course are so apparent as to need no explanation.

The only proper course under the circumstances, is to replace the old fixture and its separate trap with a modern water-closet having the trap within the bowl.

Thus far nothing but tank water-closets have been considered in this chapter. Within the last decade, however, another method for the flushing of water-closets has come into extensive use, which does away entirely with the use of flush tanks.

The device in question is known as the flushing valve, and is made in various forms by the different manufacturers, one of them being shown in Fig. 158.

Flushing valves are also much used in connection with urinals

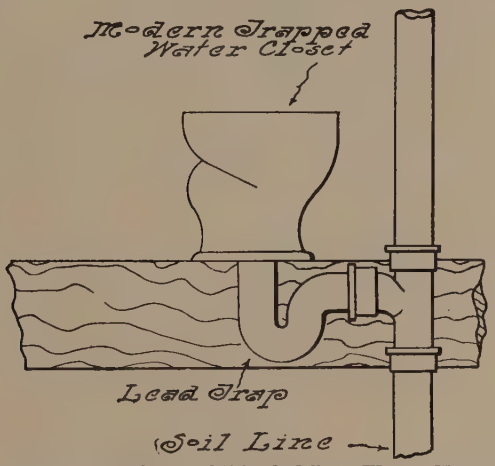


FIG. 157.—The Prohibited Offset Water-Closet.

and slop sinks. Their use thus far has been confined largely to public buildings and large work of a high grade, although in nice residence work they are also being used extensively. The flushing valve is an automatic, slow-closing valve, operated generally by means of a lever or a push button. Although the action of the different valves varies greatly, in general it may be said that its action is as follows:

When the handle or push button is released after the fixture has been flushed, the flushing valve closes automatically by means of the action of a jet or stream of water, issuing from the pressure side of the valve, which passes through a by-pass into the chamber beyond the piston-head, which is thereby forced onto its seat.

The flushing valve may be worked under direct pressure, or under tank pressure. The latter is preferable to direct pressure for this work, as tank pressure is always more uniform than direct pressure, and more positive.

The various makes of flush valves are advertised to work under various pressures, certain types being guaranteed to operate satis-

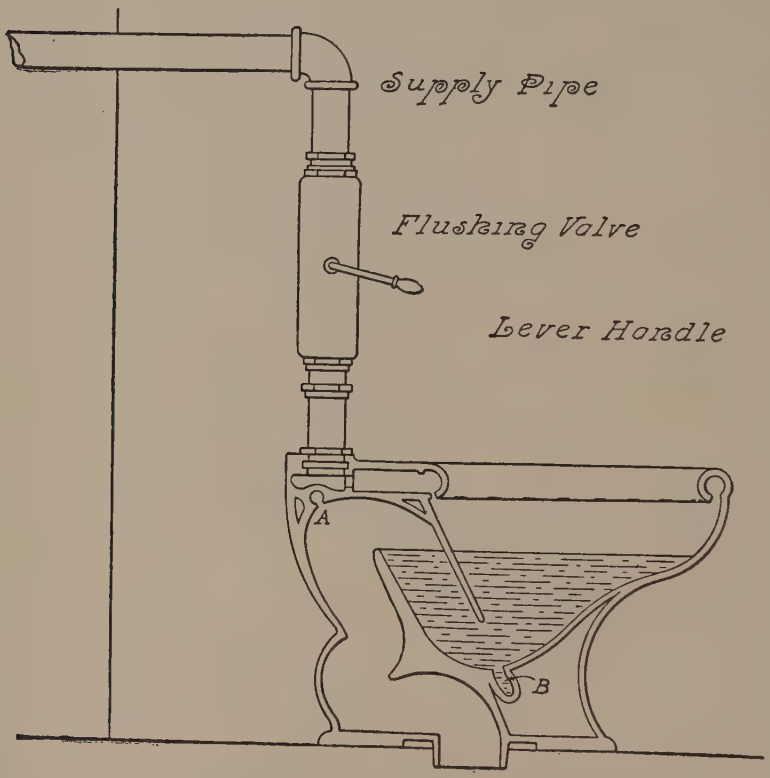


Fig. 158.—The Flushing Valve,—Double-Jet Siphon Water-Closet.

factorily through a wide range of pressure, while other makes are constructed in several patterns, each being adapted to pressure of certain limited range. Generally speaking, however, it may be said that the flushing valve must be provided with a pressure of 10 or 12 pounds to work satisfactorily.

The size of supply pipe for the various makes of flushing valves and for the various pressures varies from 1 inch to $1\frac{1}{2}$ inch. The

action and construction of these valves is so different that it is impossible to give exact data without knowing the make of the valve that is in question. Therefore in installing them, it is desirable to secure from the manufacturer the working data and instructions for connecting them under the conditions respecting pressure, number of valves on the system, etc.

In connection with the illustration of the flushing valve shown in Fig. 158, a sectional view of a double-jet siphon water-closet is given. This type of siphon-jet closet is not common and should be of interest to the reader.

It will be observed that one of the jets enters the bowl at A and the other at B, the former throwing a stream of water down the outlet leg, and the latter throwing a stream in an upward direction through the rising leg of the trap. By adding the jet A, the air is driven out of the discharge leg, thus removing the resistance to the jet B.

It would seem that the combination of the two jets must result in a very strong siphonic action, stronger than that obtained in the regular siphon-jet closet.

It is claimed by the manufacturers that this water-closet is designed especially for low-down use, that because of the lack of pressure, due to placing the tank so close to the bowl, much objection to an inefficient siphonic action has been found, which the use of an additional jet has overcome. The jet A is securely trapped. Otherwise, gases from the drainage system might pass up through the discharge leg, into the jet, and thence into the room through the flushing rim.

The frost-proof water-closet is a fixture thus far unmentioned, for which there is a considerable demand under certain conditions. It can readily be seen that it is not possible to use the ordinary water-closet bowl and flush tank in any place that is exposed to freezing temperatures, for the reason that the water in the closet trap would freeze and burst the fixture, and the same thing would happen to the flush tank.

Accordingly, whenever it is necessary to install the water-closet in cold places, the frost-proof type of closet must be used. One form of this fixture is shown in Fig. 159.

As a bowl with the trap included in it cannot be used, a hopper

closet is generally employed, protection against the entrance of gases being afforded by a trap placed below the fixture, sufficiently to be below the freezing point. The supply valve is also of necessity placed below the freezing point.

When the seat is occupied, the flush tank fills, due to the open-

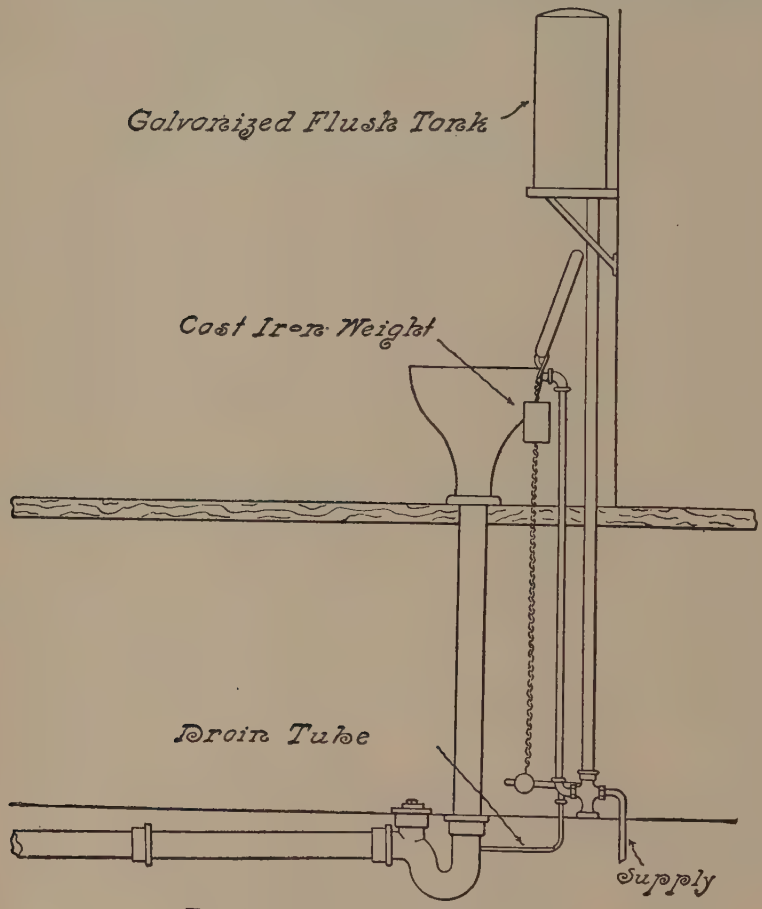


FIG. 159.—Frost-Proof Water-Closet.

ing of the supply valve by the attached mechanism. When the seat is released, the supply valve closes, and the contents of the flush tank discharge into the closet. After the flushing has taken place, the water remaining in the pipe above the valve, drains off into the water-closet trap, through a small drain tube.

It will thus be seen that when the fixture is not in use, there is no water standing in the flush tank, or at any point in the piping above the supply valve. It is needless to say that this form of water-closet work would not be considered sanitary under ordinary conditions, but under freezing conditions, as found in outhouses, sheds, etc., which are not attached to dwelling houses, such work is the best that can be made of a difficult situation. There are other forms of frost-proof water-closets, in connection with some of them the tank being placed below the water-closet. When so placed, the head due to the elevated tank is lost.

In order to provide sufficient pressure to force the water into the closet bowl, otherwise than under direct pressure, the flush tank is made to act as a pressure tank. When the seat is occupied, the water passes into this tank, compressing the air held in it, until the compression is sufficiently high to prevent its further entrance. When the seat is released, a weight attached tips it up, closes the inlet valve, and opens the discharge. The compressed air of the tank forces the water up and through the water-closet bowl, under about the same pressure as the direct supply.

In many instances, in plumbing systems for such buildings as schools, factories, etc., the range water-closet has in the past been used to some extent.

While the range water-closet is not to be compared to the individual water-closet, as to sanitary excellence, it is a fixture that is in quite extensive use, and therefore deserves attention. The old-style range was a filthy affair, but the present, high-grade makes are far superior in every respect. They are now made of porcelain or enamel-lined, there being no exposed metal surfaces, and otherwise constructed and provided with features which go far toward making this fixture of as high a standard of excellence as it is possible to secure under the conditions that must naturally surround it.

In Fig. 160 is shown one of the modern types of range water-closets, most of which are now operated by means of an automatic flush tank, combined with a strong-acting siphoning apparatus. The tank is connected to the siphon by means of an air pipe. When the tank operates, the flush exerting its influence through the air pipe, exhausts the air in the upper trap to a certain extent,

thereby forming a partial vacuum. The result of this action is that the atmospheric pressure exerted on the surface of the water standing in the opening from the range into the trap, sends the water forcibly over into the trap, filling it, and producing siphonage, which quickly discharges the contents of the range. After this operation ceases, the range fills to its regular height and is

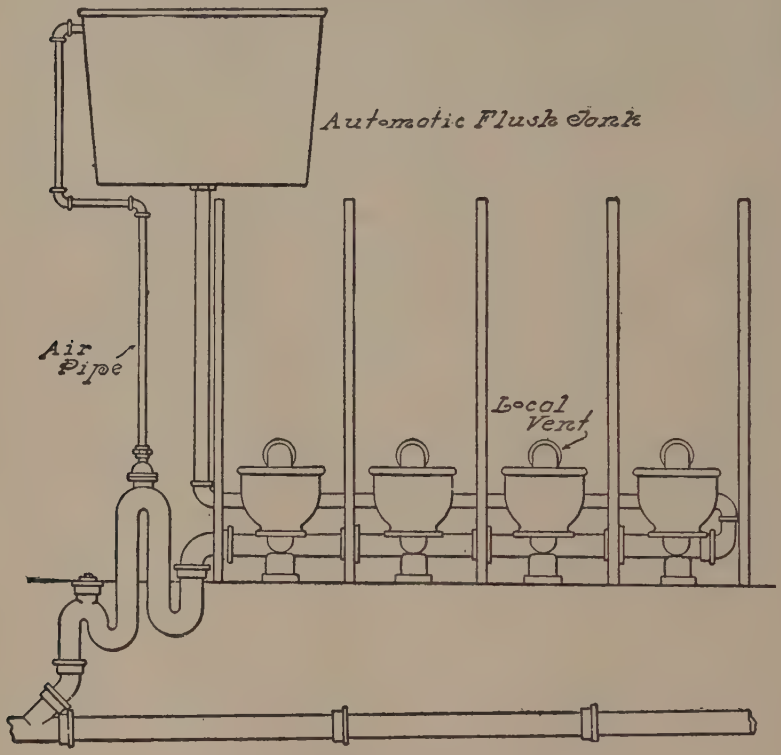


Fig. 160.—Modern Range Water-Closet.

again in readiness. The automatic flush tank may be regulated to flush at any desired interval. Each bowl is thoroughly flushed and cleansed at each flush, and the flush from the tank being also connected to the end of the range waste, adds much to rapid discharging of the contents of the range.

One of the chief objections to the old-style range water-closet, is that it was poorly flushed. This objection, then, has been very largely removed in the best makes of the present day, the flushing

and scouring features of such fixtures as that shown in Fig. 160, being very satisfactory.

Another feature that has always been very objectionable in this fixture, is the fact that the waste matter entering the range has given out into the room through the seat openings, a constant stream of foul odors, between successive operations of the flush. This has been very largely overcome by the employment of efficient local ventilation. The subject of local ventilation, by the way, is considered at length in the following chapter.

In the range shown in Fig. 160, it will be observed that each bowl is provided with a local vent connection of large size. These are carried into a ventilating duct which should connect into a well and constantly heated flue.

When a strong ventilation is thus provided, it results in reducing to a minimum, the objection above mentioned, due to the standing in the bowls of the waste matter. Whenever it is possible, a special flue should be provided for ventilating purposes, which should be heated especially for this work, if need be.

In connection with some forms of range water-closets, in which separate bowls are not used, the ventilation for the fixture is provided by a single large pipe attached to the end of the range.

It would appear, however, that the individual local vents are the most direct in their action, and therefore the most efficient. It will thus be seen that the modern range water-closet, constructed of high grade, noncorrosive material with separate bowls, thoroughly flushed, as described above, and provided with strong ventilation, is a far superior fixture to the old type—much more sanitary and satisfactory in every respect.

CHAPTER XVI

LOCAL VENTILATION

Local ventilation has been greatly improved in recent years, until now it seems difficult to understand how in its most perfect form it could be further improved upon. As it has generally been known in the past, the local or seat vent is a pipe connected to the water-closet principally, but also to the urinal and the slop sink, at such a point and in such a manner as to carry off into the outer atmosphere the odors incident to the use of the fixture to which it is attached. It may be stated that the local vent has no connection in any way with the back vent system, the purpose of the two forms of vents being entirely distinct. In Figs. 161 and 162 are shown the common methods of applying local ventilation to water-closets—the method first introduced.

It has been used mostly in connection with the water-closet, and is made of galvanized sheet iron or copper pipe, generally of 2 in. diameter. In its original form, the local vent was attached to the water-closet by a horn cast onto the side of the bowl and at a point above the water line.

The action of the local vent depends upon the fact that heated air rises. Whenever possible it should be connected into a heated flue, as in Figs. 161 and 162. The heat rising in such a flue creates a strong suction on the lines of local vent, usually powerful enough to draw into it all odors arising from the use of the fixtures connected to it.

These odors are carried up through the flue, and are discharged into the atmosphere at a point where they cannot become a nuisance. When it is impossible to connect the local vent into a heated flue, it may be carried through the roof, and a draught created by burning a small gas jet in it. A very important point is that the local vent pipe should always enter a flue above all openings into it. If otherwise connected, foul odors from the vent might escape through flue openings into rooms of the house.

In Figs. 161 and 162 are shown the two methods of constructing local vents, one consisting of a separate vent from each fixture to the flue, the other making use of one main pipe into which

. 161.—Common Method of Constructing Local Vents.

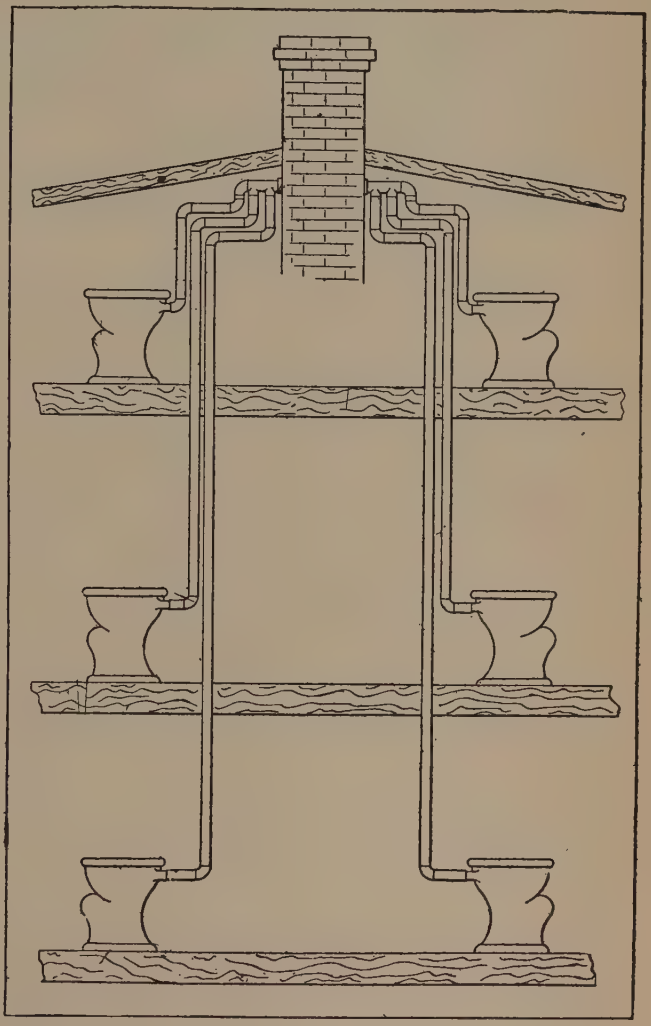


FIG. 162.—Good Method of Constructing Local Vents.

the separate vents are branched. The separate-vent system of Fig. 162 is by far the preferable.

Whenever local vents from several fixtures are connected into

a main line of vent, the latter should be of an area equal to the combined areas of the individual vents. The venting of lines of water-closets, such as found in public toilet rooms, is illustrated in Fig. 163.

In this work, the individual vents are connected into a main

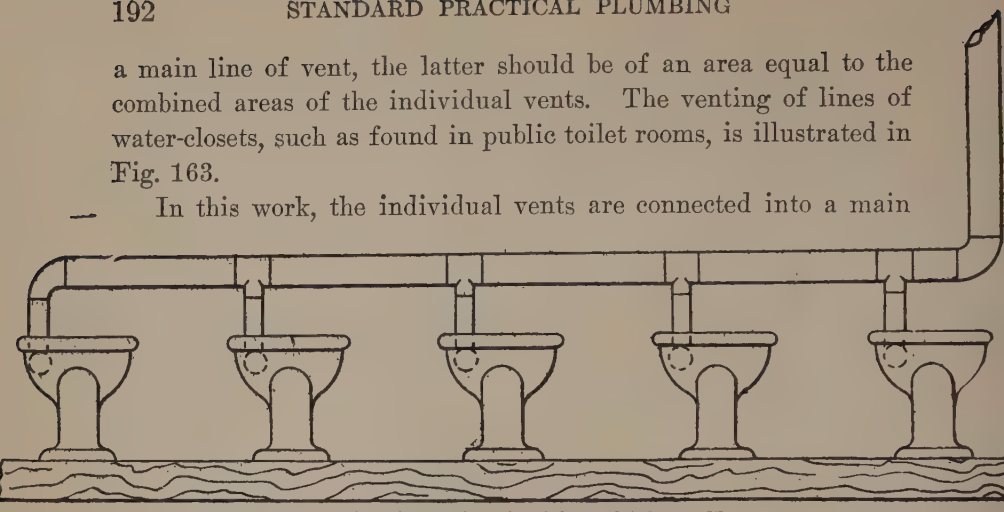


Fig. 163.—Local Venting for Line of Water-Closets.

horizontal line which is carried into a heated flue. There is not the objection to the use of a main local vent on public work that there is in residence- and dwelling-house work.

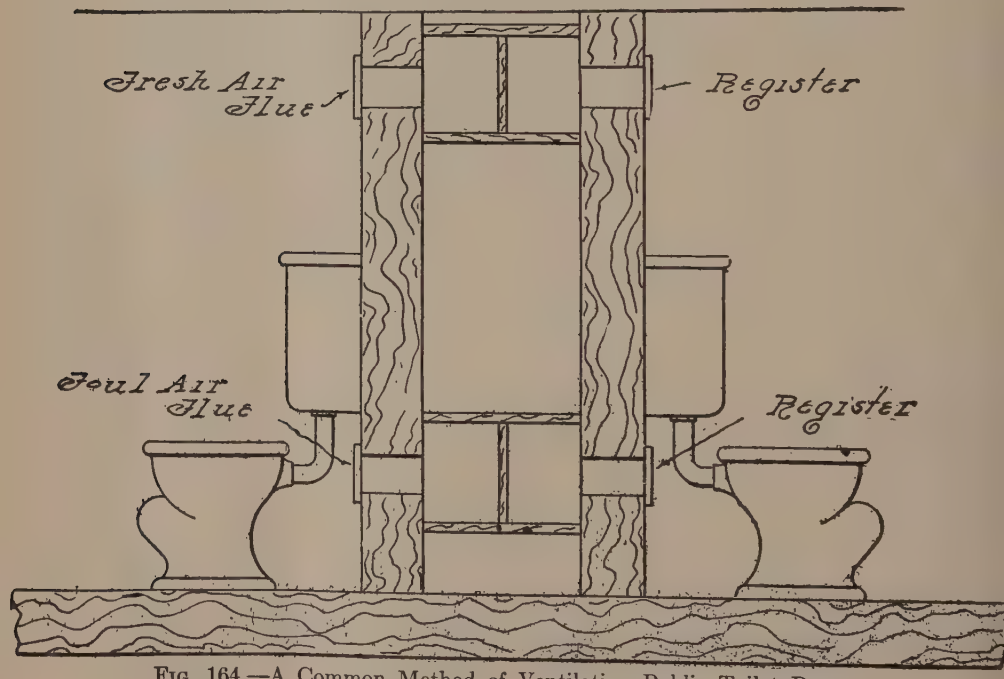


Fig. 164.—A Common Method of Ventilating Public Toilet Rooms.

The use of the local vent system described above, is still common in dwellings, residences, etc., but for large toilet rooms or public toilet rooms, this system after a time, gave place largely to another system, which is illustrated in Fig. 164. It will be clearly seen that this method does not follow closely the definition of local vents, but the subject is not complete without a consideration of it.

The illustration shows a double line or battery of water-closets, each water-closet compartment being provided with a register communicating with the foul-air duct or flue at the rear of the

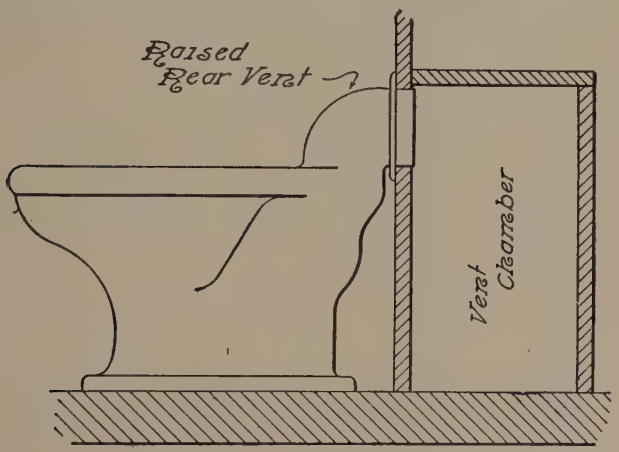
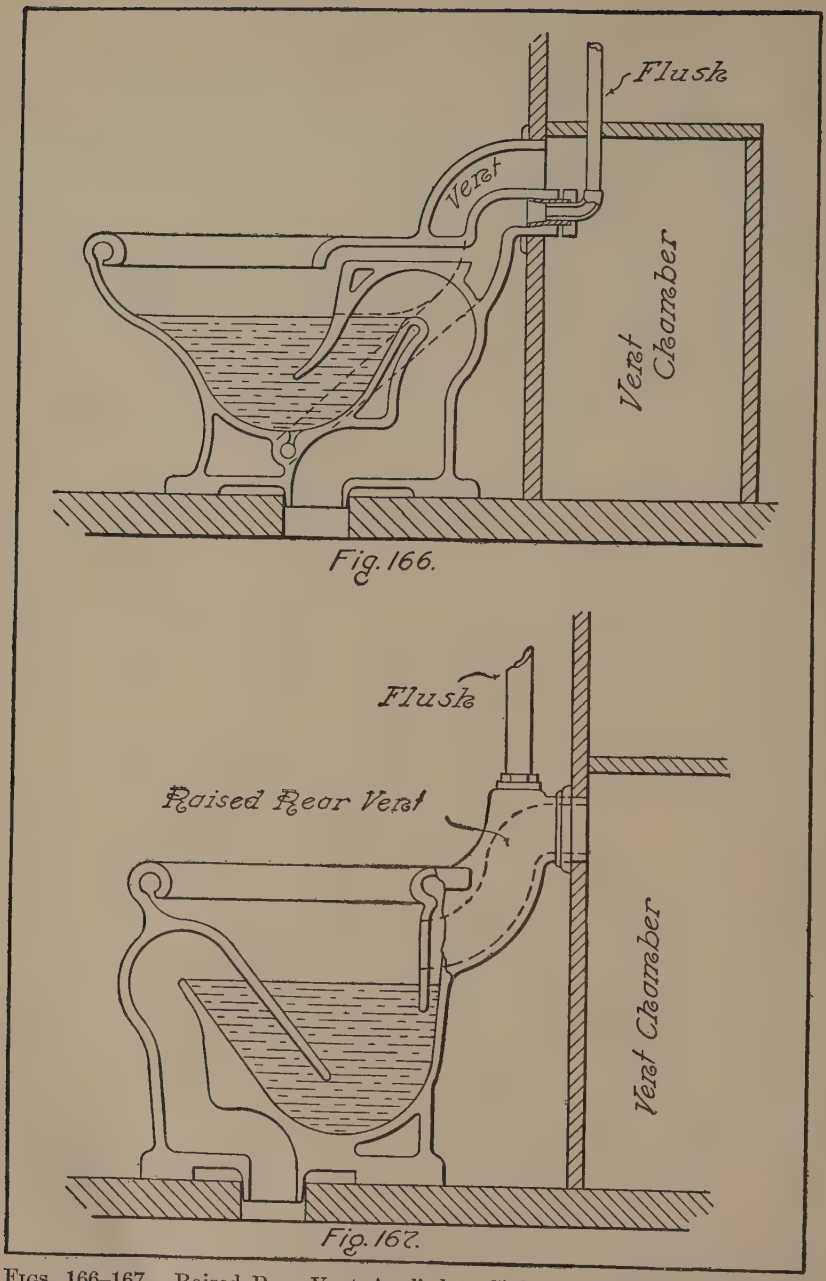


Fig. 165.—Water-Closet with Raised Rear Vent.

battery. Also at intervals along the line of water-closets, registers are placed at the ceiling for the purpose of bringing into the room a supply of fresh air. Thus it would seem that with provision for exhausting the foul air, and for admission of fresh air, this system would give perfect results.

Its weak point, however, is the fact that in order to enter the foul-air duct through the register at the side of the fixture, the foul odors and gases must first be drawn out of the closet bowl, and this gives them an opportunity to become more or less diffused in the atmosphere of the room, which is a serious objection. It may be stated at this point that much appears in the author's work "Modern Plumbing Illustrated," concerning these two methods of toilet-room ventilation, which is not given here.



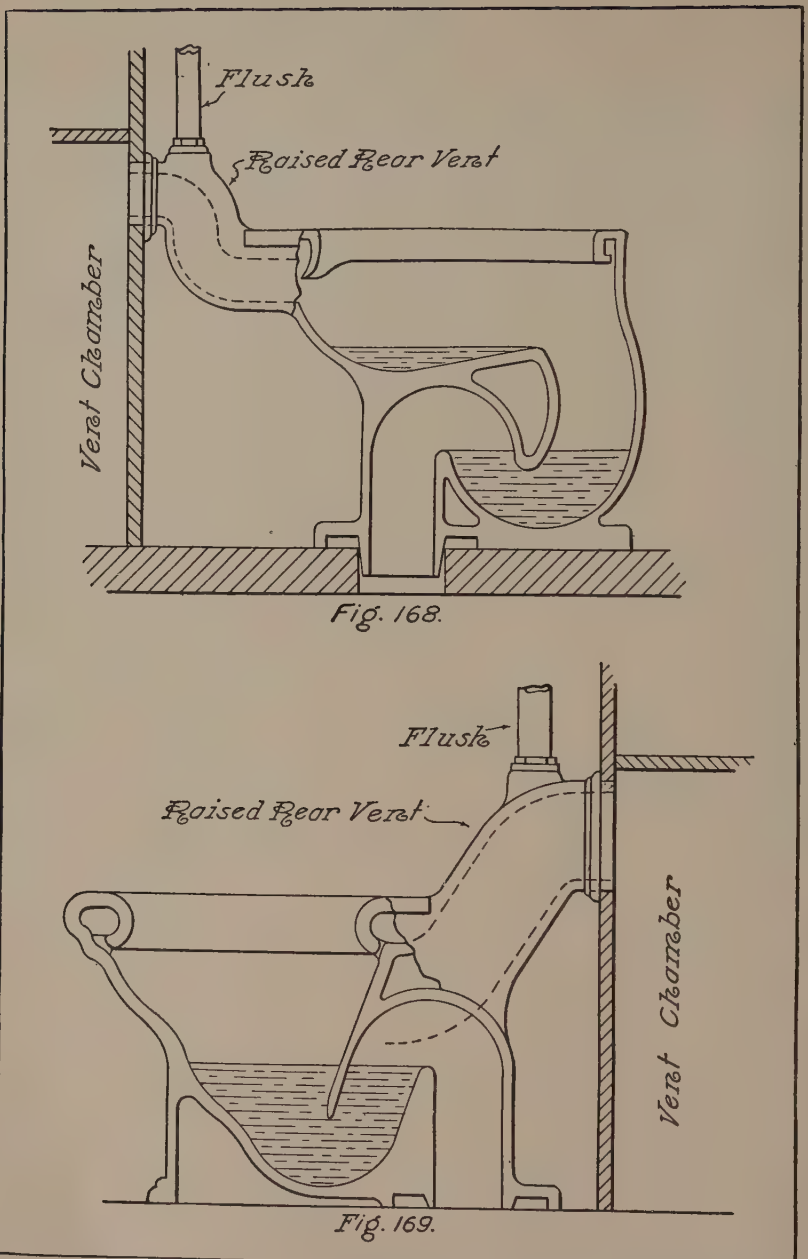
FIGS. 166–167.—Raised Rear Vent Applied to Siphon and Siphon-Washdown Water-Closets.

There is a form or method of local ventilation which has neither the objectionable feature of diffusing the odors generated, nor the objectionable feature of the method first described, which is its inadequate size of vent. The method here alluded to is the method which calls for the use of water-closets having raised rear vents, a method which gives most excellent results.

In Fig. 165 is shown one of the modern types of water-closet with the raised rear vent attached. It will be seen that instead of being of only 2 in. diameter as was the form of local vent first described, this vent is 3 to 4 in. in diameter. Furthermore, the raised rear vent is in no way unsightly, but on the other hand really adds to the appearance of the fixture. In Figs. 166–169 are shown sectional views of the most common types of water-closets with the raised rear vent applied. This is to show that the principle is one that can be easily applied to any of the modern types of water-closets. The additional expense of such a fixture over the common type is very slight.

From these four illustrations the principle of the raised rear vent is easily understood. The opening of the vent into the fixture is above the water line, and the course of the vent from the opening into the vent chamber is upward throughout. As gases and odors are generated in the use of the fixture their easiest path of escape is through this raised rear vent into the vent chamber, and thence to the outer air. Into this vent chamber each water-closet of a battery is vented. Experience shows conclusively that not only does the raised rear vent ventilate the fixture to which it is attached but it acts most satisfactorily as a ventilation for the entire room. So fully is this fact acknowledged that the State of Massachusetts now requires all public toilet rooms to be ventilated in this manner.

There has been a widespread attempt in all parts of the country to overcome the foul odors of large toilet rooms by the use of disinfecting and deodorizing devices, but this is by no means a proper solution of the difficulty, and furthermore, those rooms in which such devices are used have an atmosphere almost as repulsive as that of a room in which no attempt at caring for the odors has been made. The expense of constructing ventilating flues and ducts is small in comparison with the results obtained. If pro-



FIGS. 168–169.—Raised Rear Vent Applied to Washout and Washdown Water-Closets.

vision is made for such flues and ducts when the building is first planned, the additional expense will be very slight indeed, and not to be considered when the advantages to be gained are taken into account. There is a great variety of methods in which the ventilation system may be installed. Fig. 170, for instance, shows a

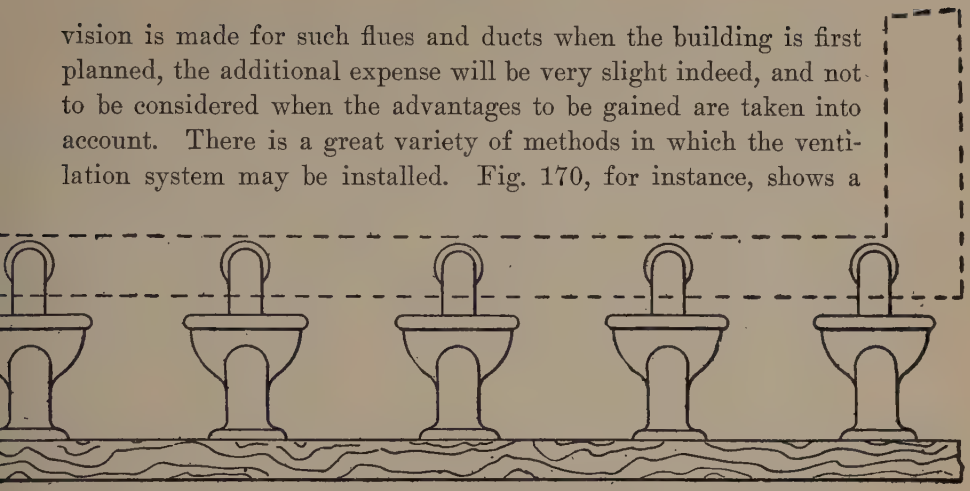


FIG. 170.—Local Ventilation by Means of Raised Rear Vent Water-Closets.

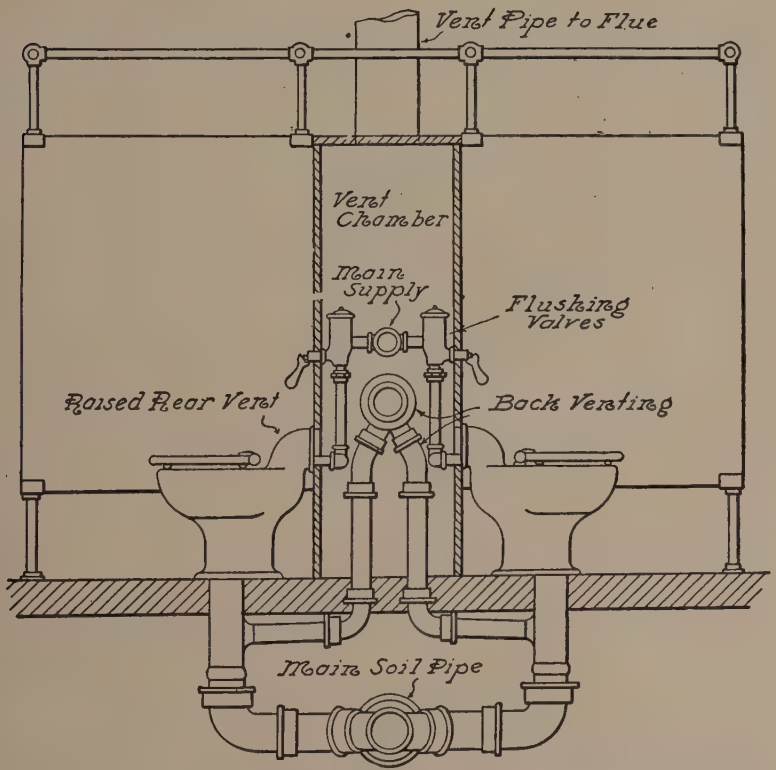


FIG. 171.—End View of Local Vent System for Double Line of Water-Closets.

common method of running a galvanized iron duct back of the partition against which the water-closets stand, thus concealing the work entirely. In Fig. 171 is shown another common and excellent method applicable to a single or double line of water-closets.

The vent chamber runs the entire length of the line of fixtures, and into it the raised rear vent of each fixture is connected. From the top of the vent chamber a pipe is carried to the flue which is to be used for ventilation. An excellent feature of Fig. 171 is that the vent chamber may be used also as a utility chamber. Its convenience in this respect may be seen from the fact that the supply pipes, flushing valves, and the back venting for the double

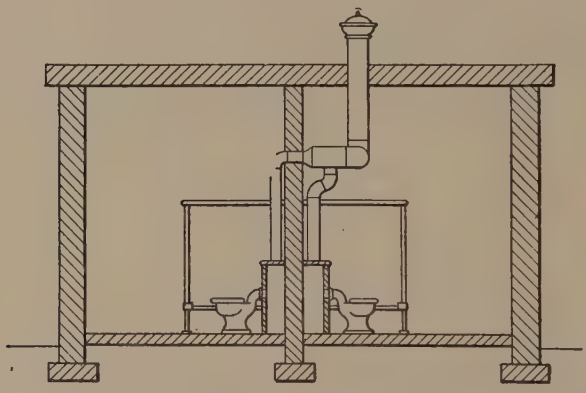


Fig. 172.—Local Ventilation for Comfort Station or Similar Toilet Building.

line of fixtures may be located in this chamber, entirely concealed from view. When so used, a door should be cut into the chamber, to allow entrance for repairs. In Fig. 172, which represents such a toilet room as might be found in a comfort station, a method slightly different is shown. In this instance, there being no flue built into the walls, a galvanized iron flue is carried through the roof, and into it the vent pipes from the two vent chambers are connected.

A ventilator at the top of the flue will add greatly to the effectiveness of the system. It used to be considered that unless local vent pipes could be connected to a heated flue they could not be effective.

This is no longer considered true, although if they can be so connected the results will be so much the better. Many toilet rooms are now provided with local ventilation in which it is impossible to use a heated flue, but this does not prevent excellent results being obtained from a flue or duct carried through the roof as in Fig. 172. In this case, however, as much assistance as possible should be given by the use of a ventilator, an electric fan placed in the flue, or a gas jet so placed. Local ventilation

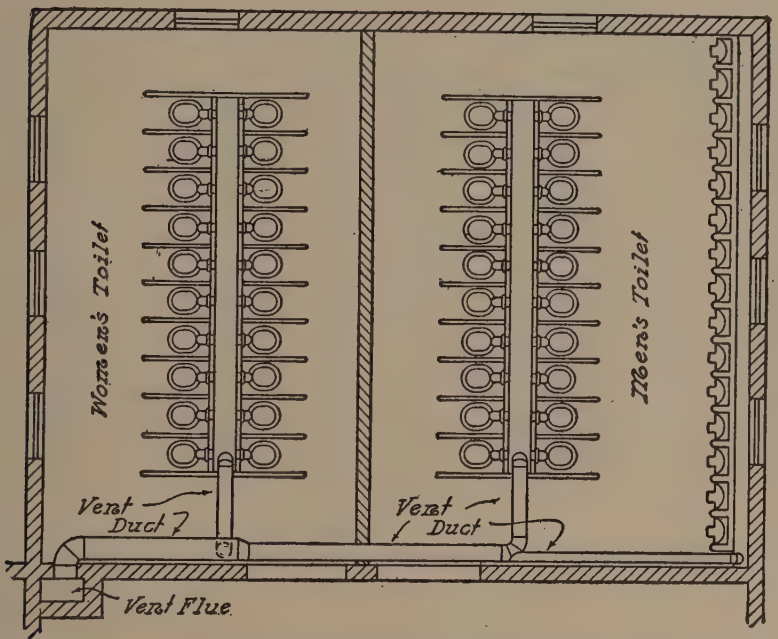


Fig. 173.—Local Ventilation for Toilet Rooms, Including Ventilation of Urinals.

may be provided in old buildings as well as in new ones, the only difference being that in old buildings the piping must often be exposed to view. However, when properly installed, such ducts are by no means unsightly. The writer recalls an old-time building in which local ventilation has recently been installed with results entirely satisfactory. The toilet rooms in this building are without natural light and without communication with the outer air, conditions under which results are generally most difficult to obtain. In this instance the pipes had to be installed exposed to

view. There was no heated flue at hand, and the ducts were consequently run through the roof with a ventilator at the outer end. Such excellent results as are obtained under these poor conditions speak well for local ventilation and for water-closets with raised rear vents.

As previously stated, local ventilation may be applied with splendid results to urinals as well as to water-closets. A system of local ventilation in which urinal ventilation is provided is shown in Fig. 173. This method of ventilation has been in use for some little time and is worthy of far greater use than it has yet obtained. Both architects and plumbers would do well to talk it and recommend its use more generally.

CHAPTER XVII

MODERN IMPROVED PLUMBING CONNECTIONS

Within a comparatively short time, a large number of especially efficient waste and vent fittings have appeared, which have great merit and have done much toward simplifying and improving waste and vent connections. In these days when the tendency is toward complication, anything which will simplify the plumbing system is to be encouraged.

The author, personally, is inclined to date these improvements

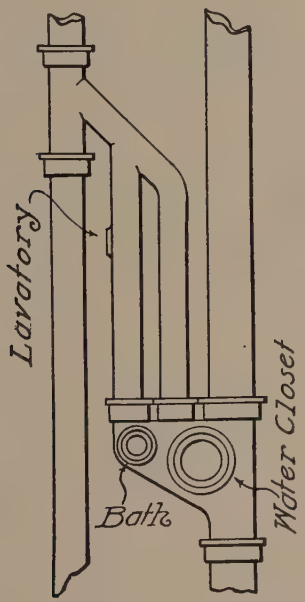


Fig. 174.—A Modern Vented Waste Fitting.

from the introduction of continuous venting, believing this system to be the indirect cause of many of these improvements. The fittings referred to present three most excellent features—they make it possible to gain a separate entrance into the drainage

system for each fixture; they allow the use of the continuous vent principle, and they greatly reduce the number of joints, the latter feature being of itself a great gain to the plumbing system. Scattered at various points throughout this work these fittings may be found, but there are others which it will be of benefit to consider in this chapter.

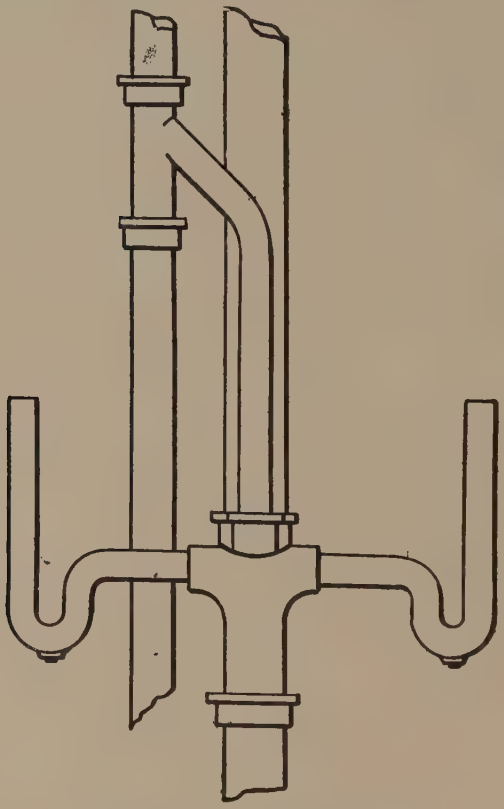


Fig. 175.—Use of Vented Cross.

In Fig. 174, for instance, is shown a fitting which illustrates the advantages to be gained from modern fittings. In this one waste fitting there is opportunity for the waste connection of water-closet and bath, and vent connection for each. The vent fitting of Fig. 174 not only does a large amount of venting with few joints and small amount of labor, but also provides a waste entrance for the lavatory.

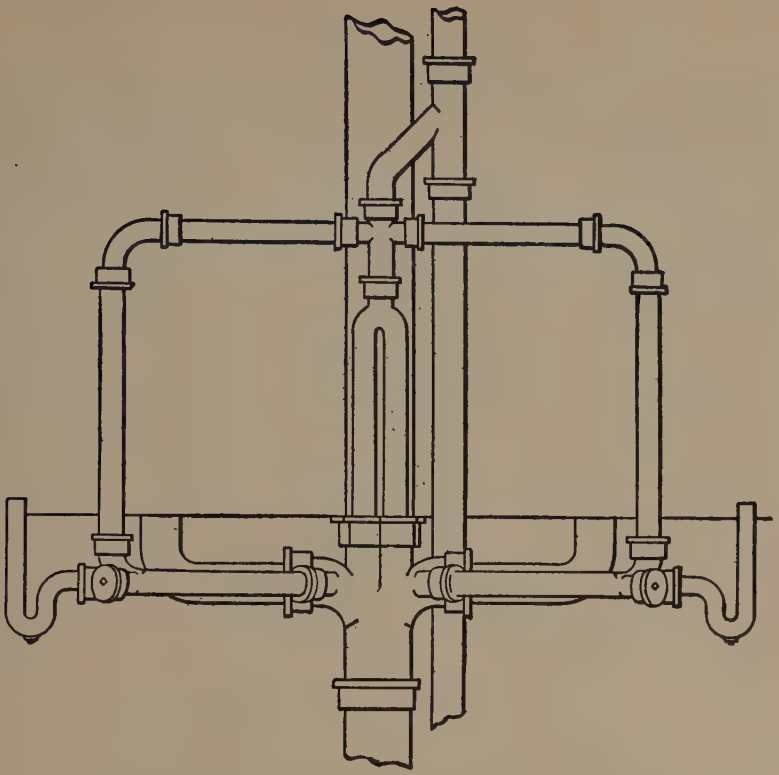


Fig. 176.—Fittings for Use in Installing Double Set of Fixtures.

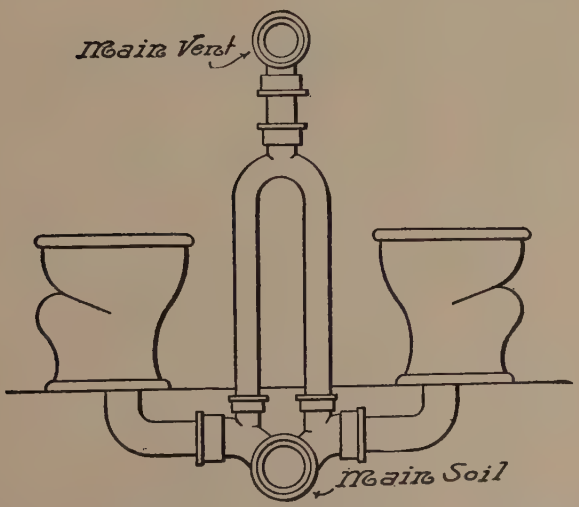


Fig. 177.—Special Fitting for Double Line of Water-Closets.

These same advantages appear also in the fittings of Fig. 175. This waste fitting, by the way, may be used for two lavatories or two bath tubs. Fig. 176 also shows a number of fittings whose use is valuable when two sets of fixtures are called for back to back, for instance, where two bath rooms on the same floor are on opposite sides of the partition.

The fitting shown in Fig. 177 also does its work, both waste

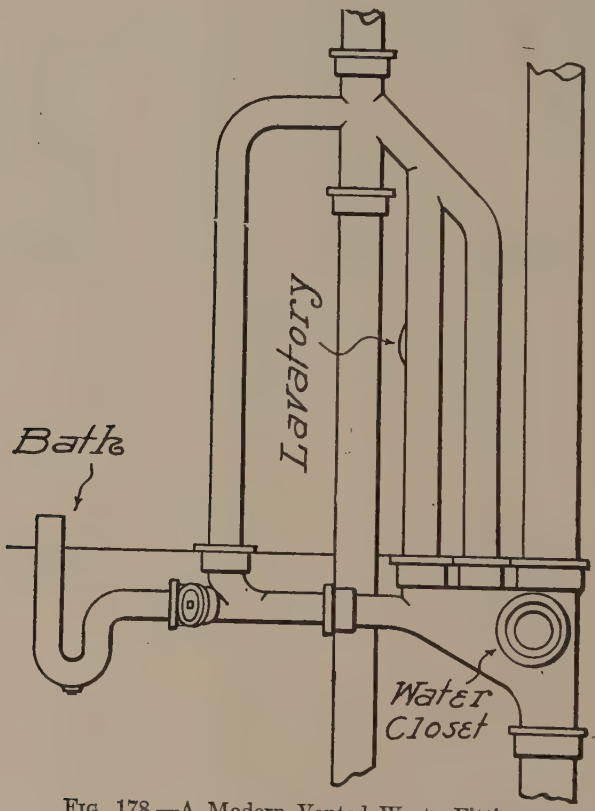


Fig. 178.—A Modern Vented Waste Fitting.

and vent, with few joints, and enables the work to be installed compactly and to the best possible advantage. Figs. 178 and 179 show fittings similar in character to those of Fig. 174, but of somewhat different design, to meet different conditions.

The additional vent hub on the waste fitting of Fig. 179 is for receiving the foot of the main vent stack. The fittings shown in

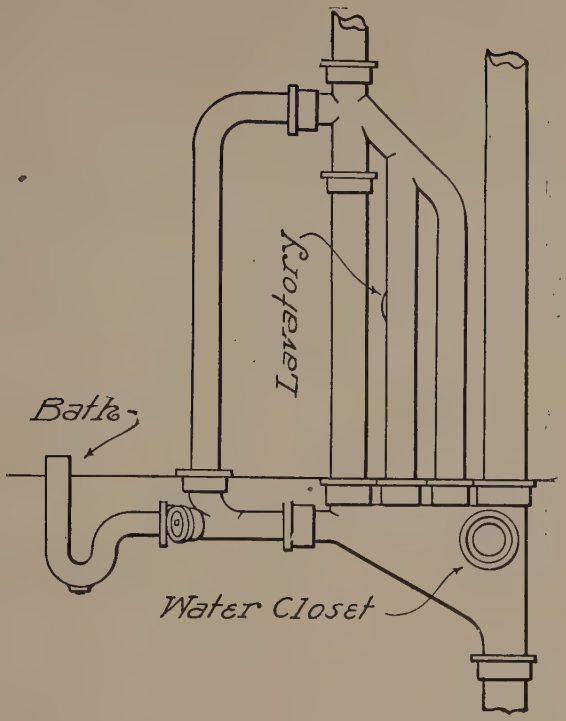


Fig. 179.—Another Modern Vented Waste Fitting.

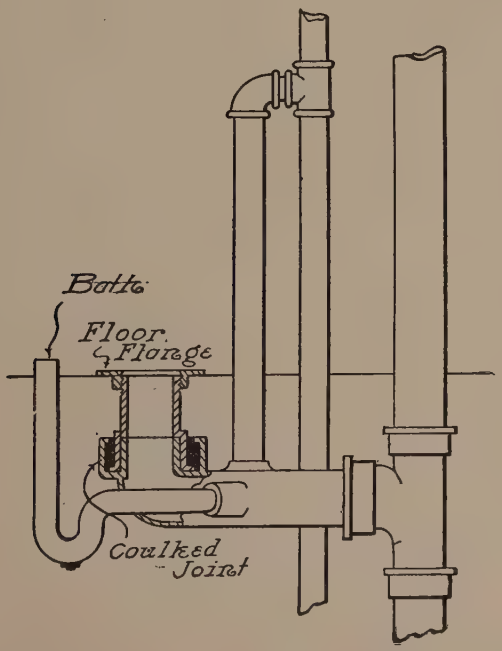


Fig. 180.—A Modern Type of Cast-Iron Water-Closet Bend.

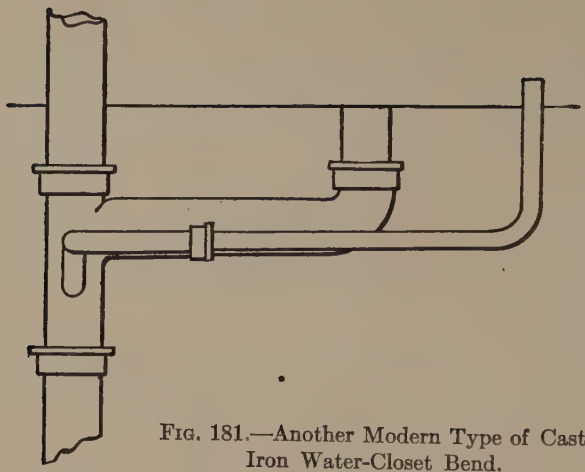


Fig. 181.—Another Modern Type of Cast-Iron Water-Closet Bend.

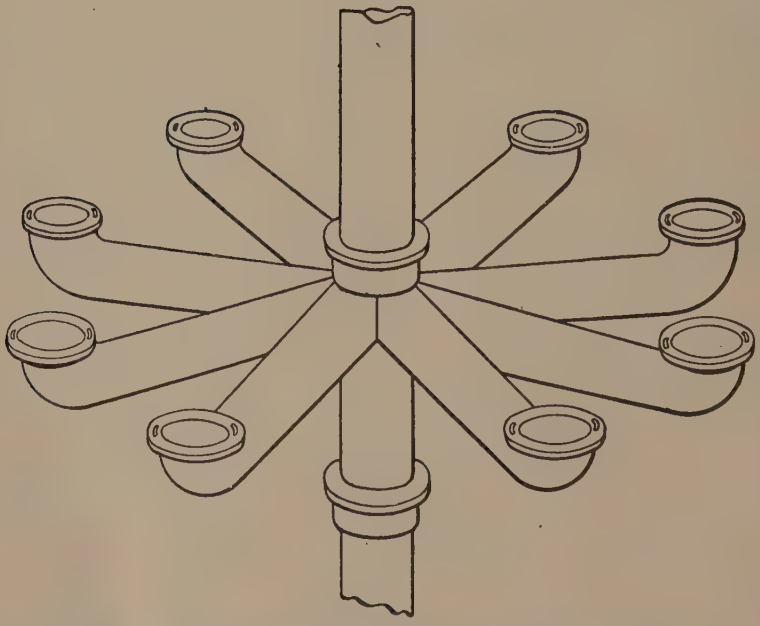


Fig. 182.—A Waste Fitting for Water-Closets Set in a Group at the Center of the Toilet Room.

these several illustrations are only a very few of the endless number of such fittings now on the market. Each one of them may be obtained with various modifications in design, until there is hardly a plumbing condition that is not perfectly covered by some one or more of these special fittings.

There is another class of fittings which have appeared only within a comparatively short time, which also are excellent in their way. We refer to the various cast-iron closet bends with their various handy features. In Figs. 180 and 181 two types of these fittings are shown. There are various other fittings of similar character, each one of them capable of being cast in a number of different modified forms, so that this class of fitting also, is capable of handling a great variety of working conditions. An especially clever fitting is to be seen in Fig. 182. This fitting is for use when a group of water-closets is to be installed in the center of the toilet room, away from any wall or partition. When it is considered what an amount of work, joints and fittings it would require to serve eight water-closets if put in under these conditions with ordinary fittings, the value of this fitting is seen. In fact, the work could not often be done if common fittings were to be used.

It is true also of many of the other special fittings, that by means of them work can sometimes be installed which could not possibly be installed with common fittings.

The description and illustration of these fittings give but a faint conception of the great number that are to be found on the market, but they will serve to show what great advantages come from their use, as indicated earlier in this chapter, and to indicate also the great saving in labor that they effect.

CHAPTER XVIII

PLUMBING FOR RESIDENCES, DWELLINGS, ETC.

The subject of residence plumbing is one of the important branches of plumbing construction, quite different in many respects from such lines of work as the plumbing for public buildings, factories, etc., and indeed more or less different in many of its details, from the plumbing of apartment buildings.

The residence bath room especially, is a distinct feature in plumbing construction, upon which almost any amount of expense

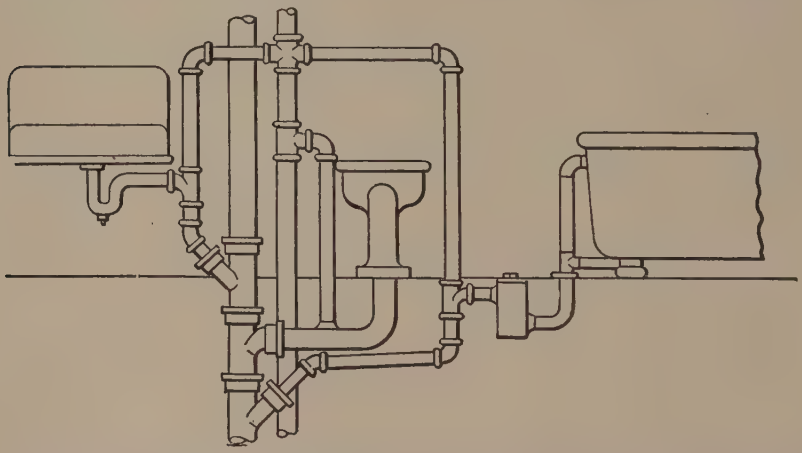


Fig. 183.—Connections for Bath Room. Separate Entrance into Stack for Each Fixture.

may be lavished, and in the appointments of which much taste may be displayed.

In Fig. 183 is shown an arrangement for the waste connections of the bath room, which is a good one, inasmuch as it provides a separate waste entrance into the stack for each of the fixtures. In addition to the three ordinary bath-room fixtures, there are several others which may often be found in the more extensive residences.

Among these are the sitz bath and foot bath, illustrations of which are given in Figs. 184 and 185. Their connections are very similar to those of the bath tub.

The child's pedestal bath, and the bidet are fixtures now used to some extent in residence bath rooms.

A fixture which adds much to the comforts of the bath room, is the shower bath. While the public shower bath is generally quite a costly and complicated affair, the residence shower bath commonly used, is simple and easy to install.

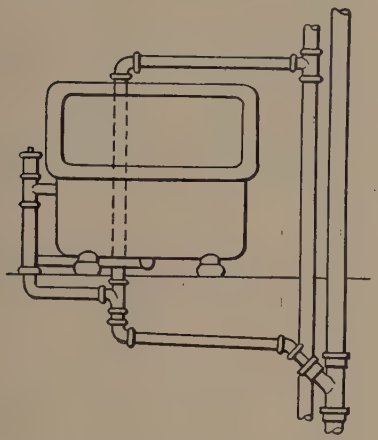


FIG. 184.—Connections for Sitz Bath.

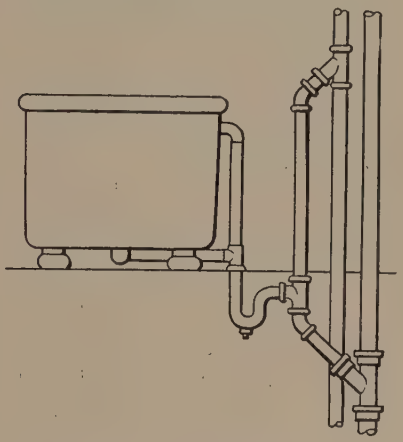


FIG. 185.—Connections for Foot Bath.

The connections for the fixture, which is known as a receptor, are shown in Fig. 186.

The slop sink, the connections for which appear in Fig. 187, and the pantry sink, as shown in Fig. 188, are necessary to the complete equipment of the modern residence.

A method of connecting laundry tubs is shown in Fig. 189, the only objection to this method being the fact that with the trap at the end of the line of tubs, it leaves a considerable length of exposed waste, to throw out odors through the waste openings of the several tubs. The laundry tubs are sometimes located in the kitchen, particularly in the case of flats and apartment houses, in which case the connections of Fig. 190 are good.

This allows both kitchen sink and laundry tubs to secure separate waste entrance into the drainage system.

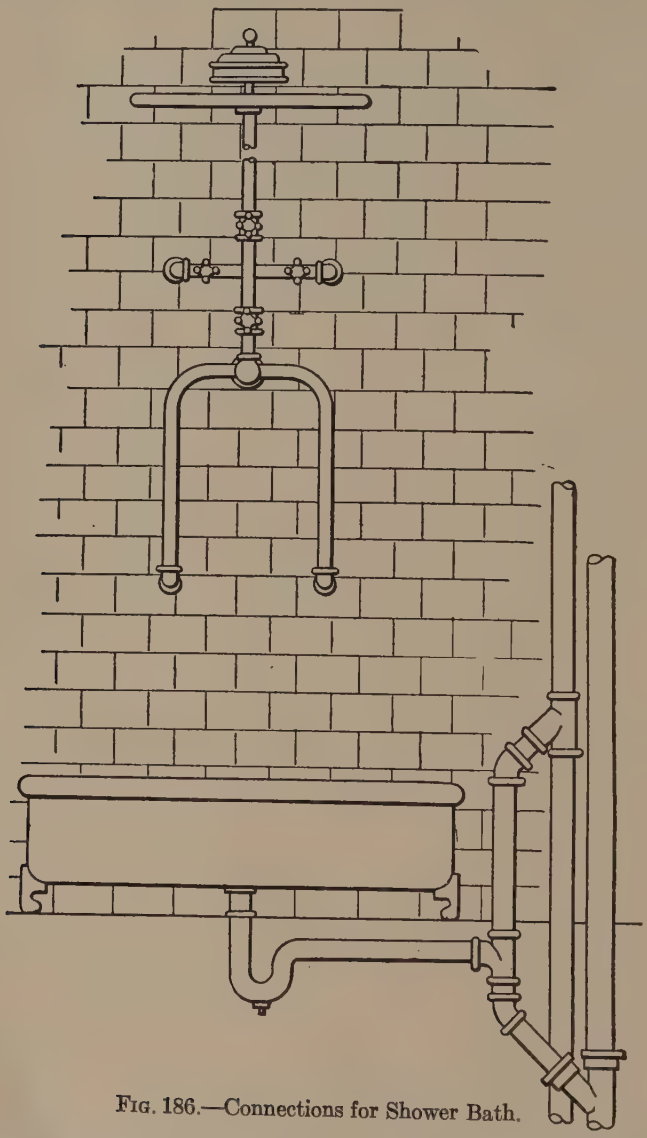


Fig. 186.—Connections for Shower Bath.

These two fixtures should never be connected into one trap, a practice which is often followed, but which is to be condemned under all conditions.

The connection of the refrigerator is also an important matter, inasmuch as the contamination of food through unsanitary connections is necessarily a source of great danger to the health of the inmates.

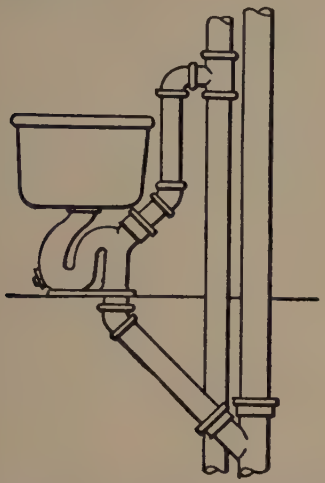


FIG. 187.—Connections for Slop Sink.

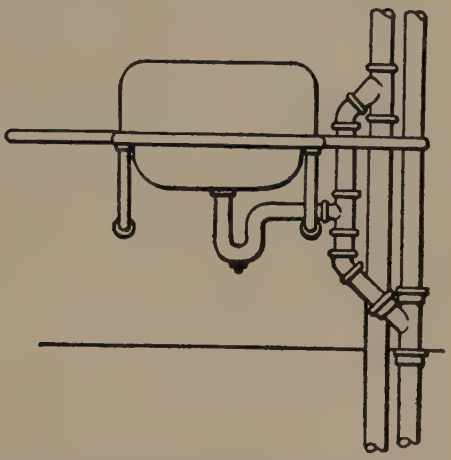


FIG. 188.—Connections for Pantry Sink.

Fig. 191 shows an entirely wrong method of connection for the refrigerator, but nevertheless, this and other similarly unsanitary connections are often made.

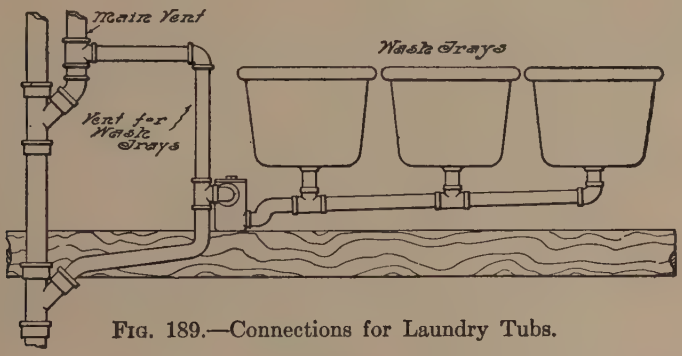


FIG. 189.—Connections for Laundry Tubs.

The proper method may be seen in Fig. 192. The drip pan should be trapped, and dripped into a drip sink which should be connected to the drainage system in the same manner as any

other plumbing fixture. Under these conditions the refrigerator is not only protected by two traps, but there are two breaks be-

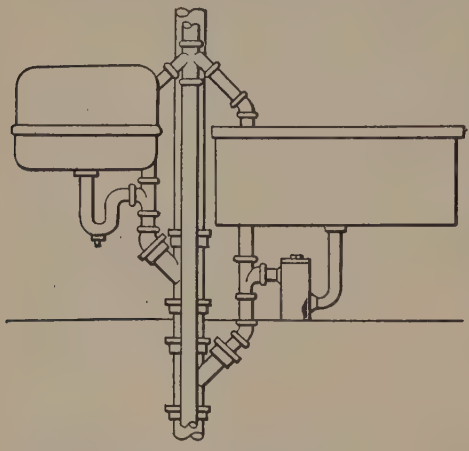


FIG. 190.—Connections for Kitchen Sink and Laundry Tubs.

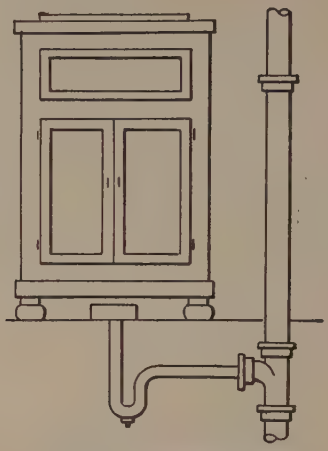


FIG. 191.—Wrong Connections for Refrigerator.

tween the drainage system and the refrigerator, one between the two traps, and another between the refrigerator and its drip pan. It is advisable to have the refrigerator trap drip into the sink

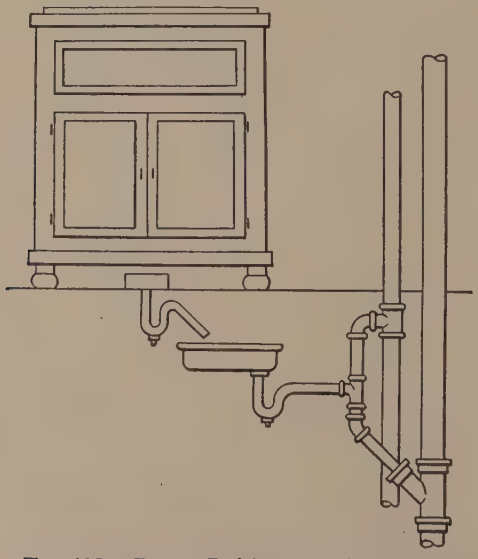


FIG. 192.—Proper Refrigerator Connections.

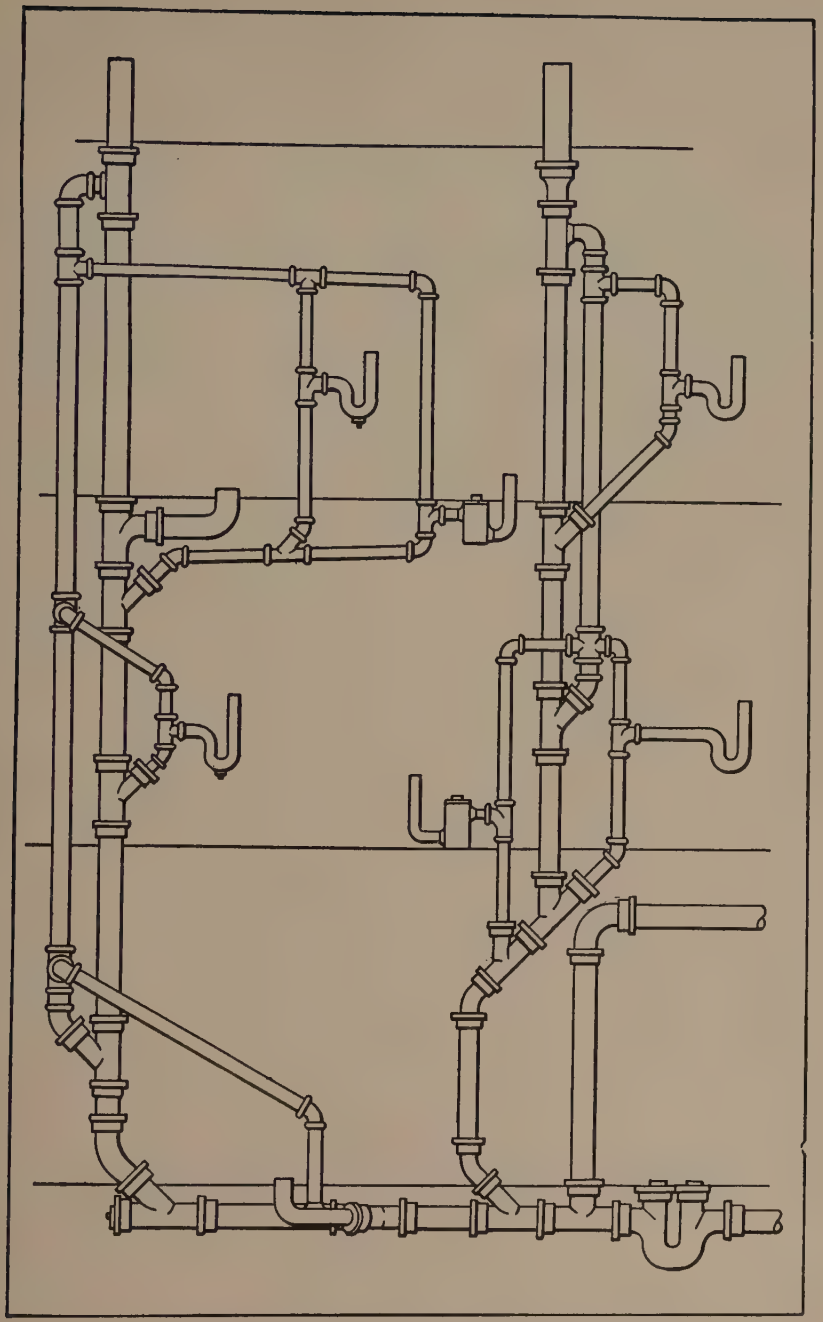


Fig. 193.—Plumbing for Residence in Readiness for Water Test.

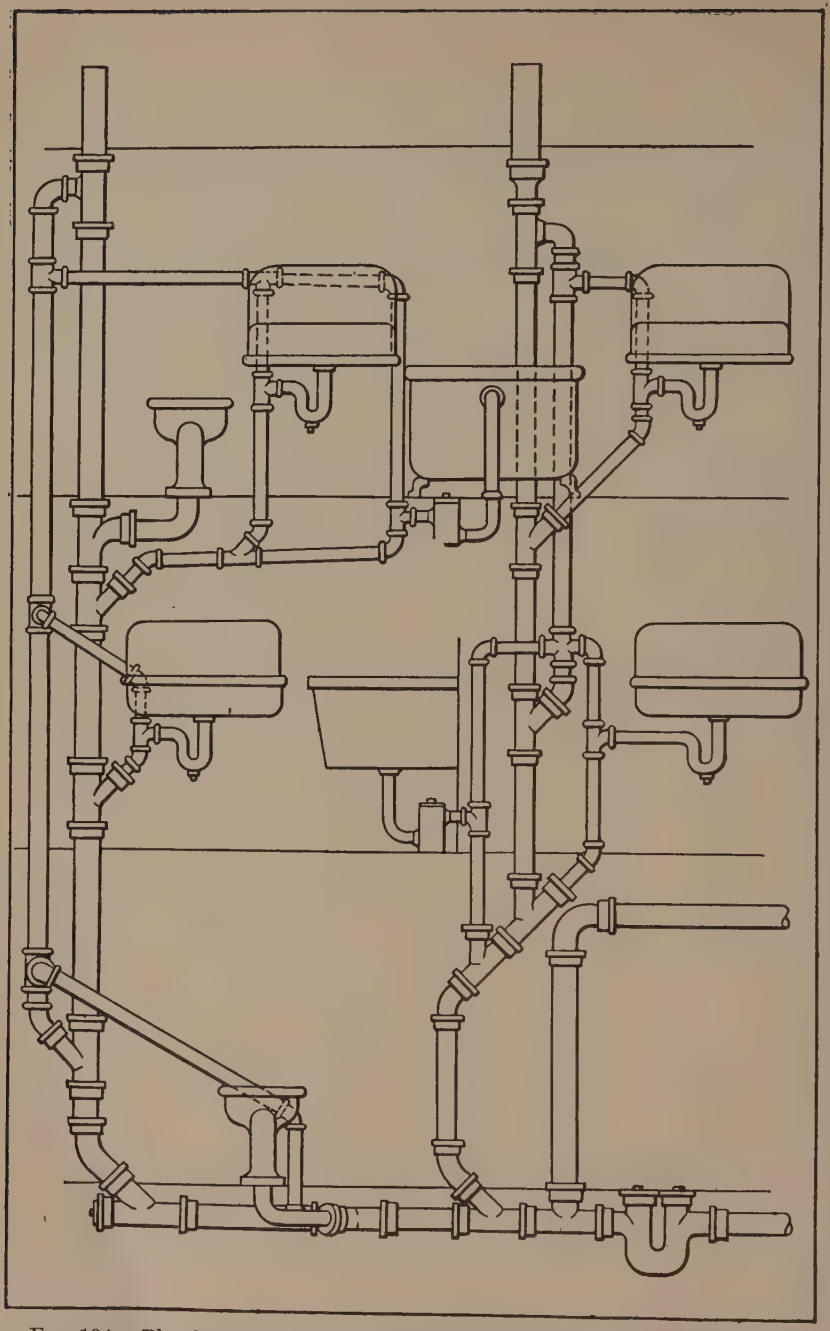


Fig. 194.—Plumbing System for Residence, Showing the Work of Fig. 193. Completed.

in the manner shown, rather than to have the openings of the two traps in line with each other vertically.

With these connections and intelligent use and precaution, there should be no reason why the refrigerator should not waste into the drainage system with as much safety as any other fixture.

The foregoing gives an idea of the details of connections for the different fixtures commonly found in residences.

In Fig. 193 is shown an elevation of the complete plumbing system for a residence, after the roughing has been completed, and the work is ready to receive the water test. This system is constructed according to the practice which is generally followed in most sections of the country. It is capable of improvement, however, by the application of continuous venting in place of the crown venting shown. The same system after it has reached completion, with all fixtures in position, is seen in Fig. 194.

CHAPTER XIX

PLUMBING FOR SCHOOLS, HOTELS, FACTORIES, STABLES, ETC.

The plumbing systems for schools, factories, etc., and for such buildings as apartments, are very much more complex than those for residences and small dwelling houses, and call for the solution of problems of a considerably different nature. In this larger work, especially in the toilet rooms of schools, hotels, and various other public buildings, long lines of fixtures must be provided for, and upon such work much judgment and skill may be displayed.

This is true, for instance, in the connections for lines of lavatories. The old method of performing this work was according

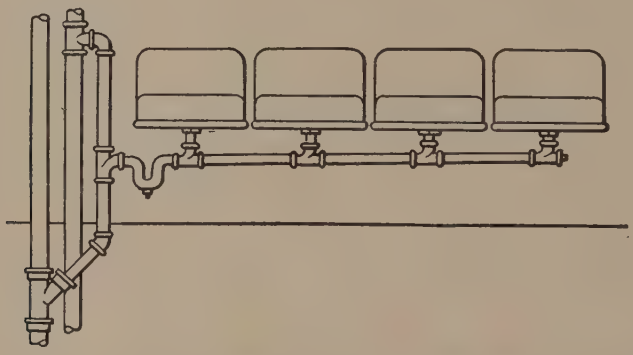


Fig. 195.—Poor Method of Connecting a Line of Lavatories into a Single Trap.

to Fig. 195, in which a single trap is made to serve the entire line. This is obviously a poor method.

Whenever the trap stops up, as it is almost sure to do sooner or later, not one only, but the entire number of lavatories is rendered useless, until the stoppage is removed. Another objectionable feature is the fact that foul waste pipe running the entire length of the line of lavatories is constantly throwing its impure

odors into the room through the several lavatory outlets. An improvement over this method is shown in Fig. 196, these connections

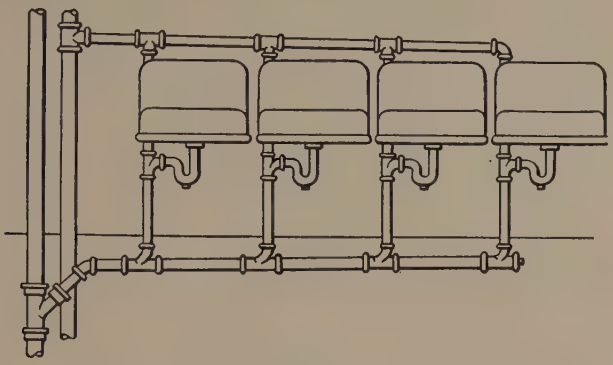


FIG. 196.—Proper Connections for Line of Lavatories.

giving each lavatory separate entrance into the main waste line, with opportunity for a cleanout in the end of it, by means of

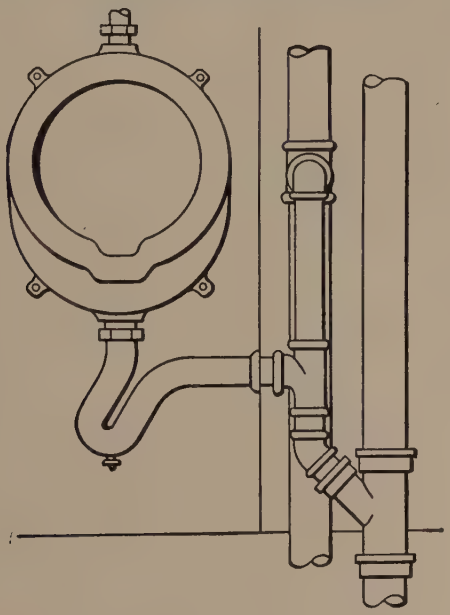


FIG. 197.—Connections for Urinal.

which any stoppage on the main may be removed. The chief objection to this method, however, is the great possibility of the

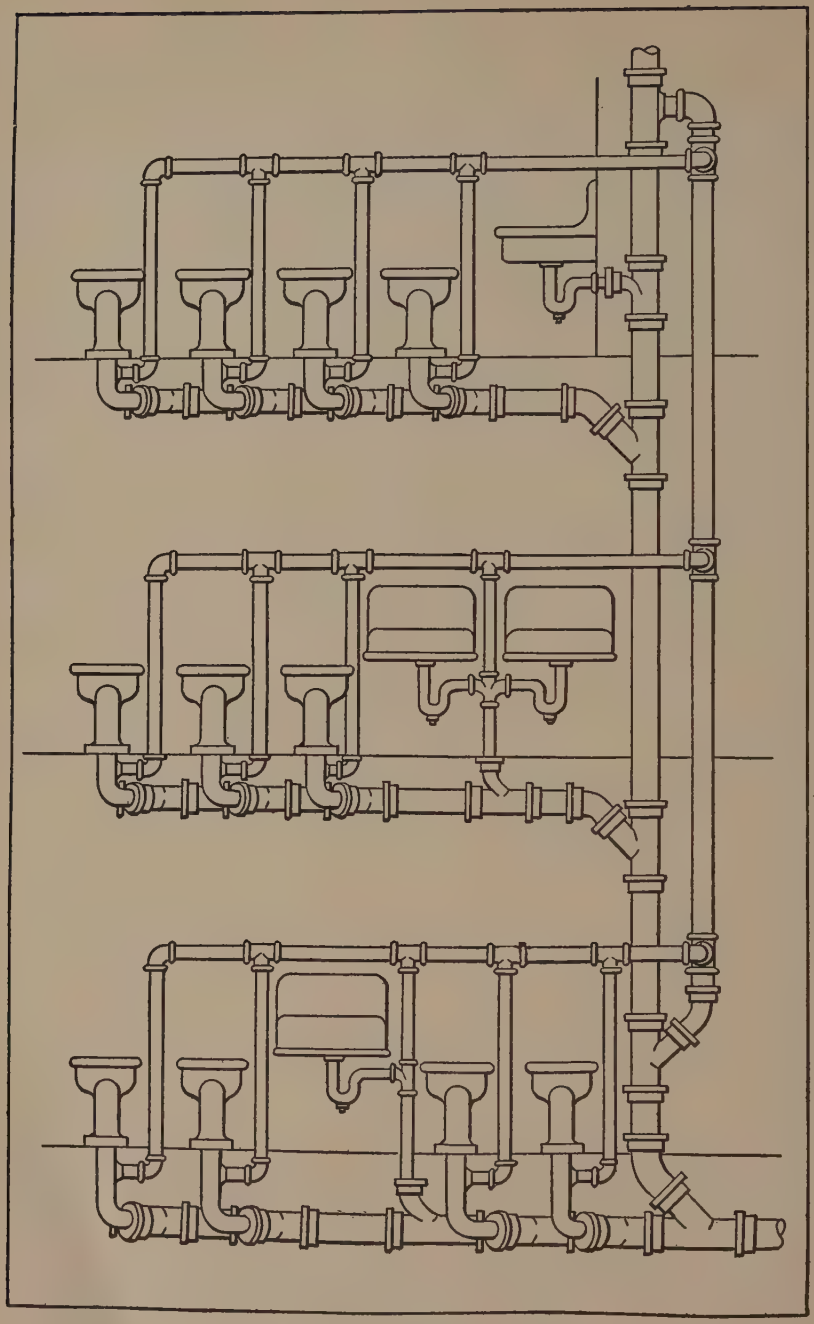


FIG. 198.—Ordinary Method of Venting for Toilet Rooms of Schools, Factories, Etc.

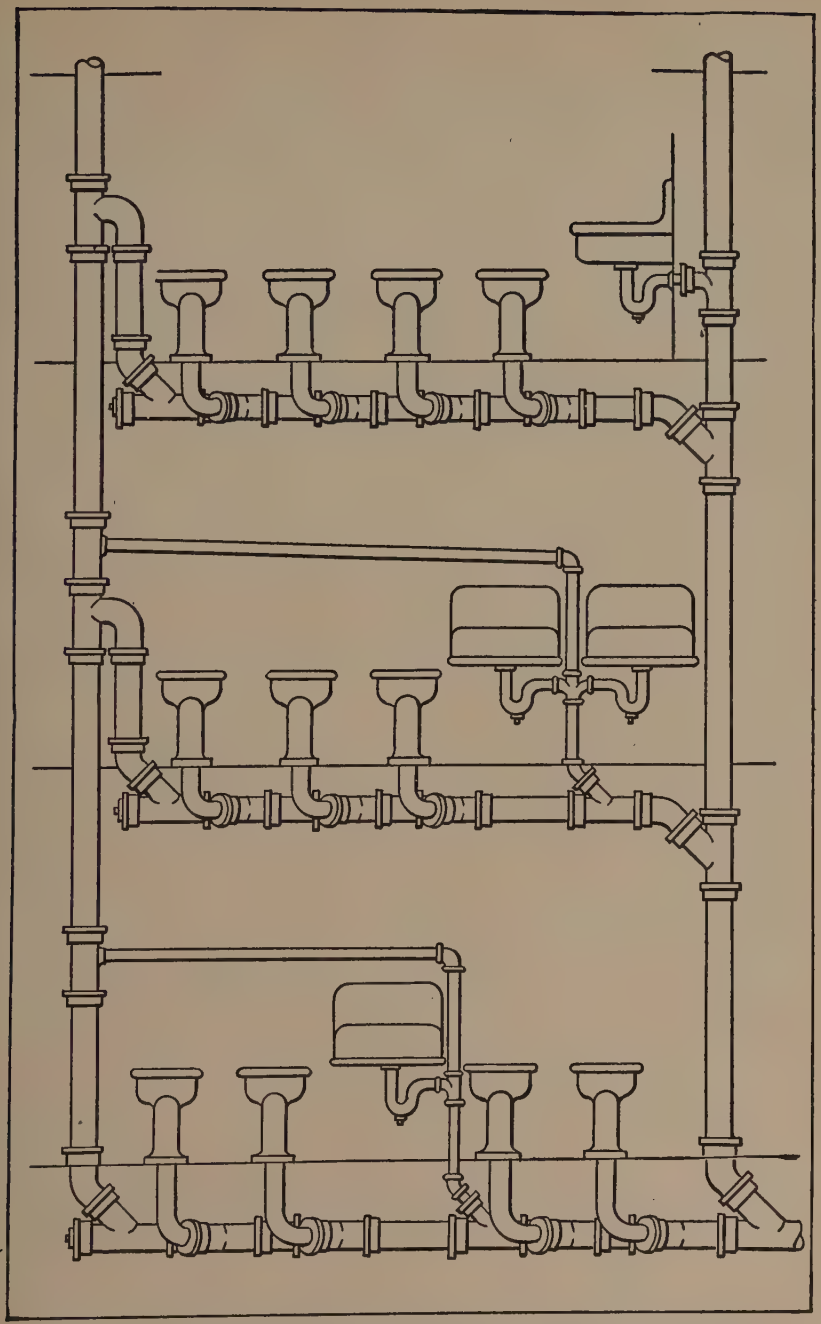


FIG. 199.—Circuit Venting for Toilet Rooms of Schools, Factories, Etc.

stoppage of the vent openings into the traps. This feature, as shown elsewhere in this chapter, may be very successfully overcome by the use of continuous venting. In another chapter, also, may be seen an illustration of a line of lavatories connected up with continuous vents. Not only is their use a great improvement from a sanitary standpoint, but ofttimes it results in great economy in the expense for labor and material, especially when two lines of lavatories or sinks back up to each other. Lines of urinals may often be connected to advantage in this same way. Although sometimes used on residence work, the urinal is a fixture found principally in large buildings of a public or semipublic nature. The common type of urinal and its connections are to be seen in Fig. 197. The subject of urinals, by the way, is considered at length by the author in his "Modern Plumbing Illustrated."

For public work, the massive porcelain urinals now in use are excellent, inasmuch as they are very cleanly, a feature greatly to be desired in urinals, which as ordinarily constructed and installed, are the most objectionable of all fixtures.

The pedestal urinal is one of the modern forms of urinal which is also very desirable.

In Fig. 198 is shown an elevation of the plumbing of toilet rooms for such buildings as hotels, schoolhouses, factories, etc., installed according to the approved methods in vogue in most cities at the present day. In Fig. 199 is shown an elevation of the same system installed with circuit vents, which subject is considered elsewhere in this work.

In many cases public toilet rooms may be served to better advantage by the circuit-vent system than by that shown in Fig. 198. It will often be found to decrease both the complication and the expense of the work. When there is but one toilet room, and it is desired to provide the water-closets with a circuit vent, the work may be performed according to Fig. 200, the vent in this case being known as a loop vent, from the manner in which it loops over the line of fixtures.

Very often, especially in public buildings, owing to the style of building construction, trap vents must be run to a point above the ceiling, and then horizontally into the main vent line, as seen in Fig. 201. The latter illustration shows the work put in under

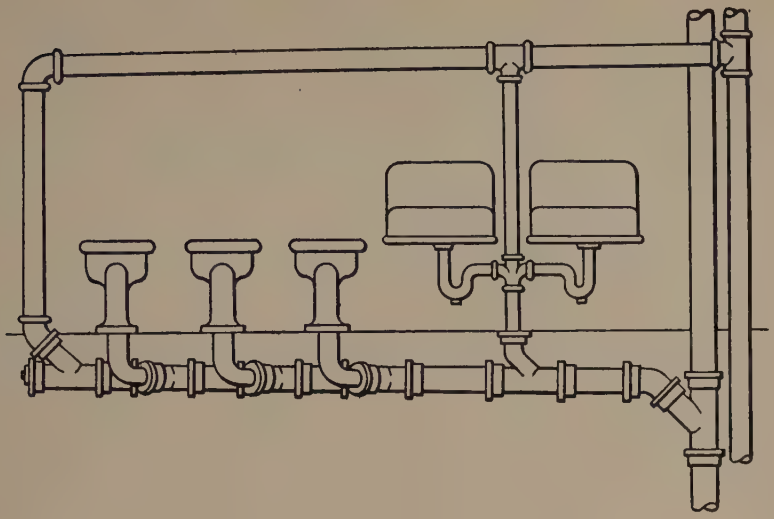


FIG. 200.—The Loop Vent.

the Durham system, which has come into extensive use in public-building work, notwithstanding the serious objections to its employment.

In the matter of ventilation for public toilet rooms, the local

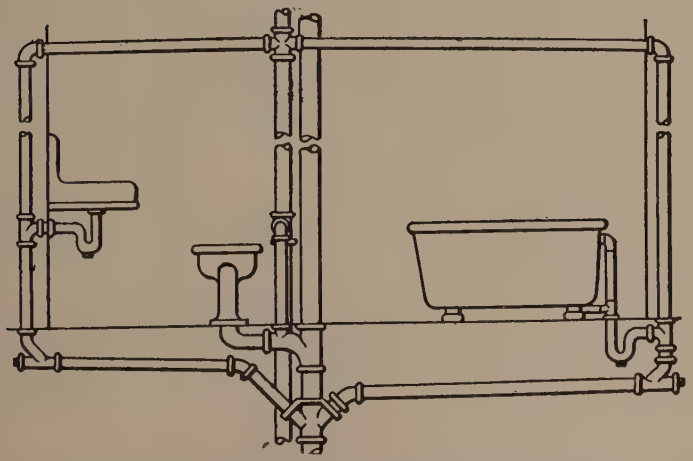


FIG. 201.—Bath-Room Connections, Durham System.

vent does good service when the service required of it is not too great. On large work, however, a method often followed is shown in Fig. 202, the foul air being drawn out through foul-air ducts, and fresh air forced in through fresh-air ducts.

Wash sinks for school and factory use and for similar pur-

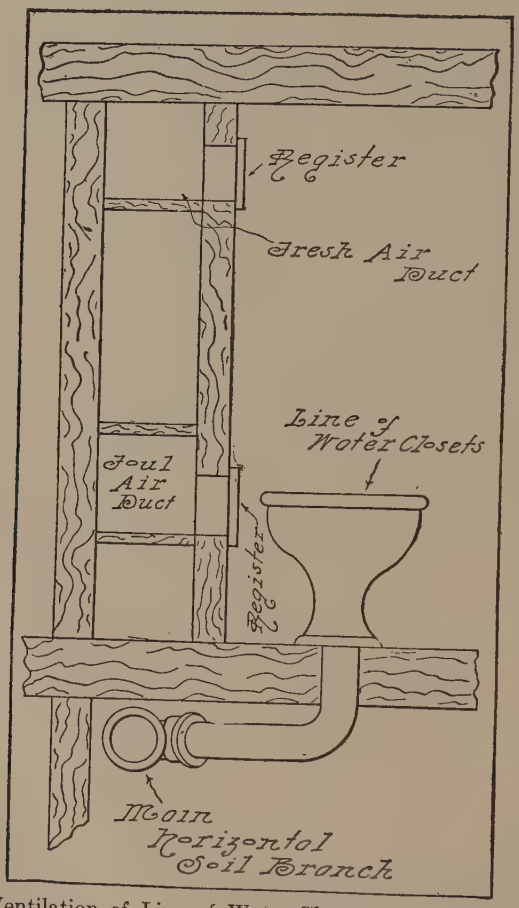


Fig. 202.—Ventilation of Line of Water-Closets in Public Toilet Room.

poses, are a subject of importance. For this purpose there are several good makes that may be obtained, among them those shown in Fig. 203, which represents a single line.

In Fig. 204 an end view of a double line of these sinks is given, and in Fig. 205 a top or plan view of the double line.

From the latter, it will be seen that the battery is made up of separate sinks, which are so made that they may be butted up to each other, enabling the installing of batteries of any desired length.

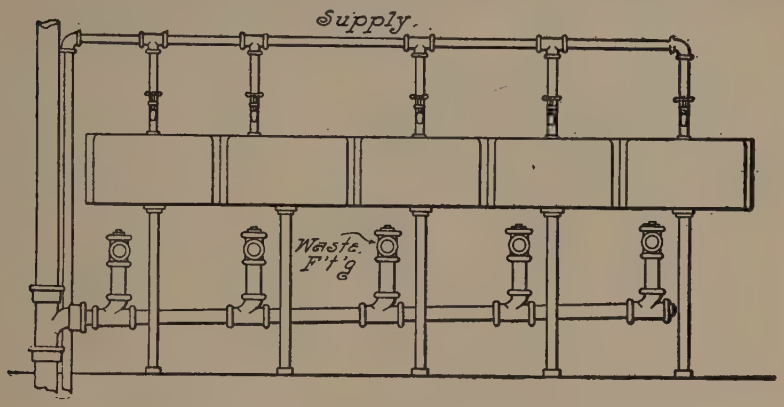


Fig. 203.—Wash Sinks for Schools, Factories, etc.

Such sinks are often placed at the center of the wash room, in which position the venting of the many traps and the running of the main vent would often be a difficult and awkward matter.

Therefore, in those cities where it is allowable to use non-

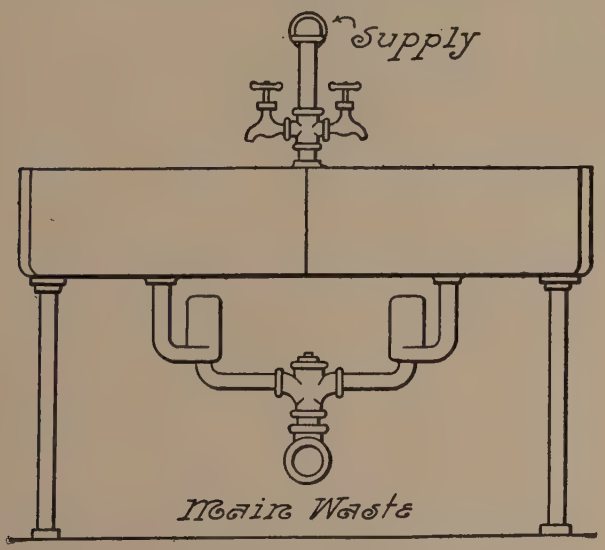


Fig. 204.—End View of Double Line of Wash Sinks.

siphonable traps without vents, the connections shown in Figs. 203 and 204 may be used to great advantage. This gives each fixture a separate waste entrance and a cleanout, with a cleanout at the

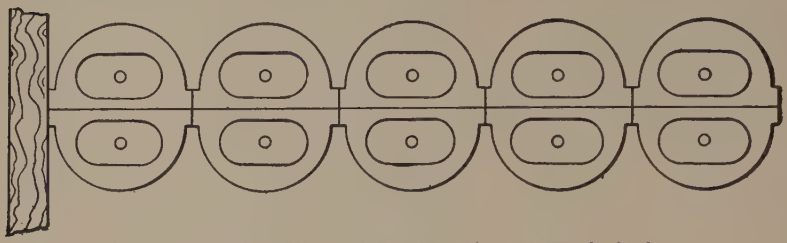


Fig. 205.—Plan View of Double Line of Wash Sinks.

end of the line of main waste pipe. Above the line of sinks, as shown, a line of supply is run, with outlets for each fixture, which are supported on the fixture itself. This line of supply answers also for holding towels, etc.

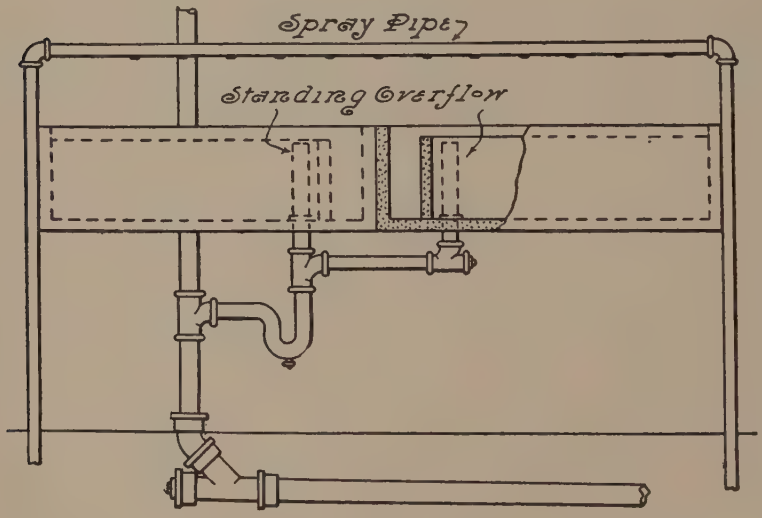


Fig. 206.—Factory Wash Sink.

If there is no difficulty in running vents, the continuous-vent principle may be employed on these fixtures. To carry this out, the work should be installed as in Figs. 203 and 204, but half-S traps used instead of other styles.

Another excellent form of factory wash sink is that shown in elevation in Fig. 206 and in plan in Fig. 207.

The sink is made in sections, generally of slate, and may be installed in any length by using a sufficient number of sections.

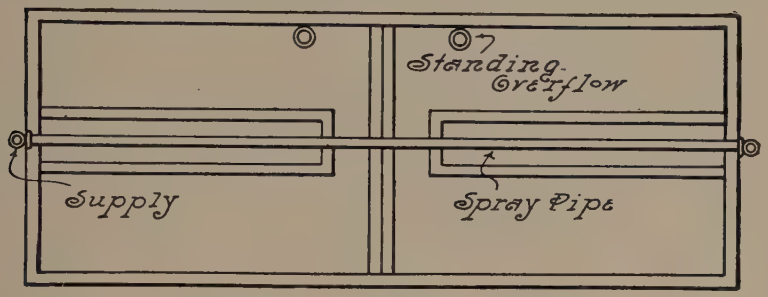


Fig. 207.—Plan View of Factory Wash Sink.

The novel feature of this sink is its center compartment. Into this falls the water from the spray pipe which runs above the center of the sink. From the center compartment the water constantly overflows into the main body of the sink. This arrange-

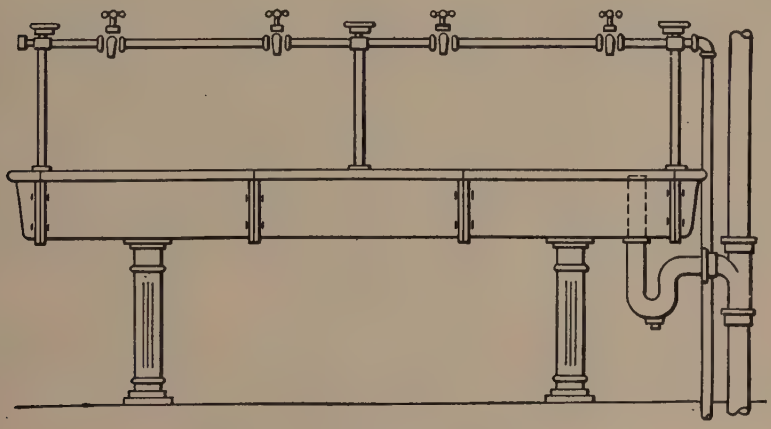


Fig. 208.—Sectional Wash Sink.

ment keeps the inner compartment always filled with clear water for washing the face, a great objection in most factory sinks being the absence of any such convenience. A standing overflow is provided for each sink section.

Another form of sectional sink is shown in Figs. 208 and 209. It is of cast iron, and the sections are bolted together to give any required length of sink.

The supply is carried through the length of the sink, and directly over its center, with a bibb taken out at intervals. The supply pipe is supported on brackets which are bolted to the sink, each bracket being supplied with a soap dish.

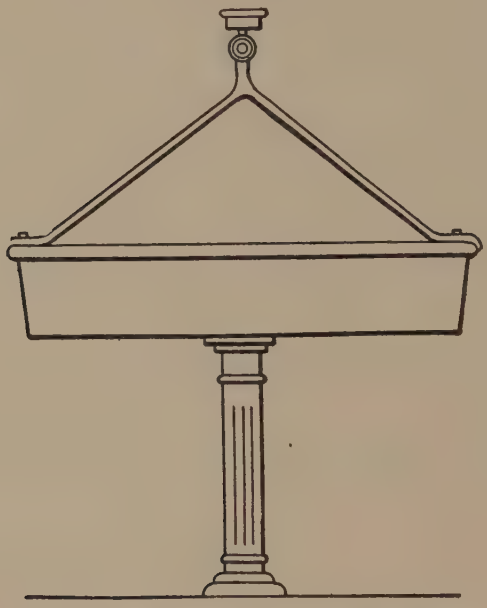


Fig. 209.—End View of Sectional Wash Sink.

The matter of drinking fountains is of importance in school work and in other public buildings.

Connections for the common form of drinking fountain are given in Fig. 210, concerning which there is no special novelty. Over this form of fountain, which necessitates the use of the same drinking cup by all that use the fixture, there has been great improvement in recent years.

The improved drinking fountain is shown in two forms in Figs. 211 and 212.

In these fixtures, the supply is connected directly to one or more bubbling cups.

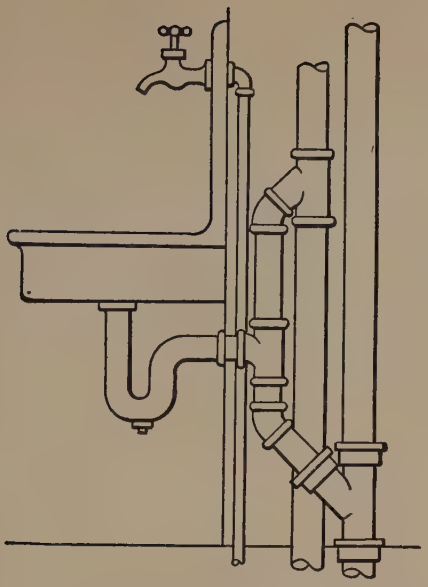


Fig. 210.—Common Form of Drinking Fountain.

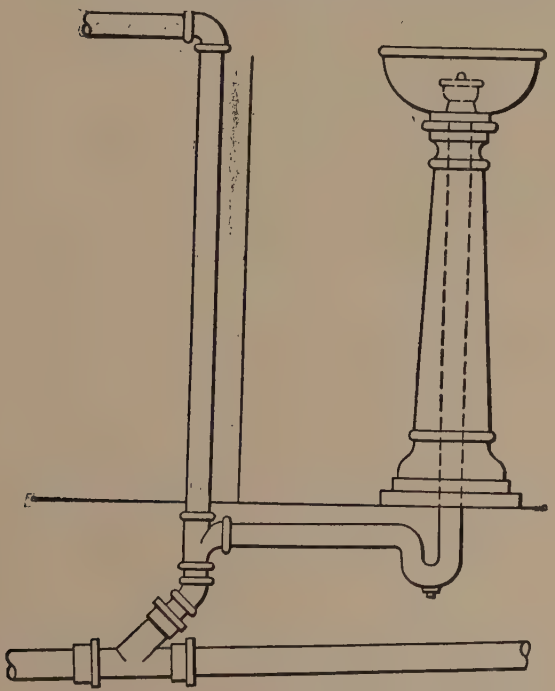


Fig. 211.—A Sanitary Pedestal Drinking Fountain.

By pressing down on the rim of the cup, the water is made to spurt or bubble up to any desirable height, according to the adjustment. This enables the water to be drunk without the use of a drinking cup, which is naturally a very much more sanitary method.

Such fountains as these are extensively used for all public purposes, both indoors and out of doors.

In public toilet-room work, it is often required to operate water-closet flush tanks automatically. A very good method is one adopted by several of the best manufacturers, in operating the

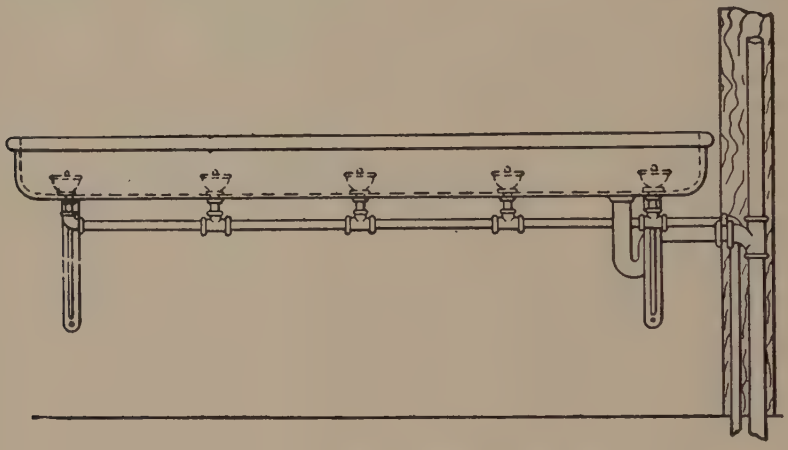


Fig. 212.—A Sanitary Drinking Fountain.

flush by means of levers attached to the seat in such a manner that when it is released these levers trip the flush valve in the tank. Another method is similar, but operated by the opening of the door to the water-closet compartment.

Flushing valves have in the last few years been rapidly coming into use on public work, thereby doing away entirely with flush tanks. In many cases the best method of handling public water-closets and urinals is by means of an automatic flushing system, which thoroughly flushes these fixtures at intervals of a few moments. The great objection to this course is the fact that foul matter entering the water-closets and urinals must often have to remain several minutes before it is flushed out. Therefore, on such work it is wise to have a very strong system of ventilation.

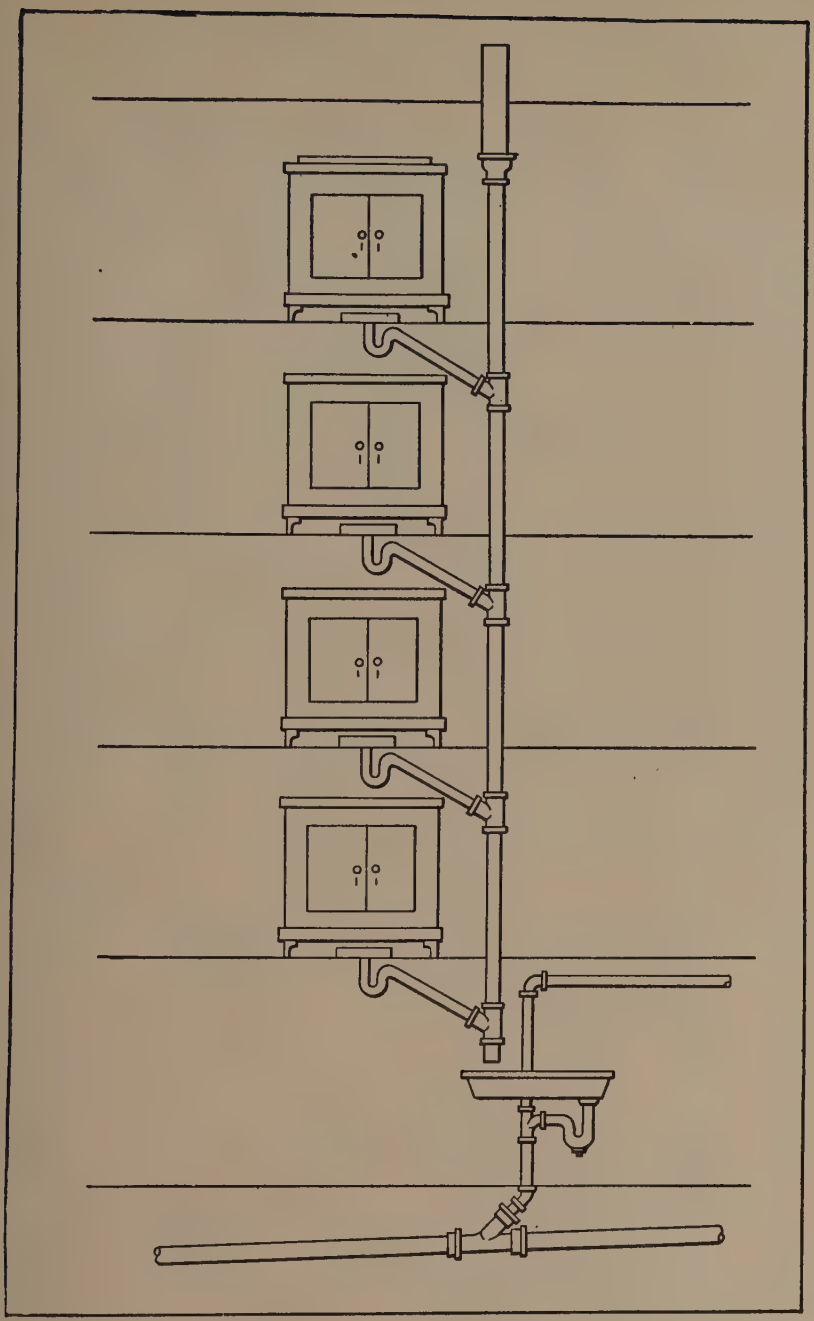


Fig. 213.—Connections for Line of Refrigerators on Several Floors.

In "Modern Plumbing Illustrated," by the author, the subjects of flushing valves and automatic flushing are illustrated and considered exhaustively.

The use of lines of refrigerators in large buildings, especially

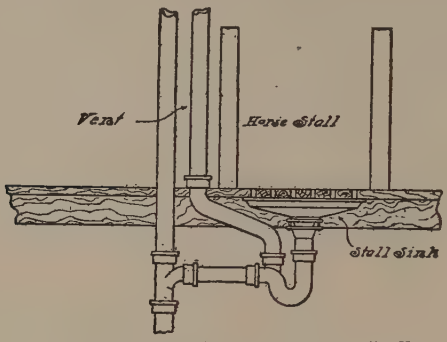


FIG. 214.—Plumbing for Horse Stall.

in apartment buildings, is a matter which may properly receive attention in this chapter.

In the chapter on residence plumbing, the connections for a single refrigerator are shown, but when a line of two or more refrigerators is to be connected with the drainage system, the

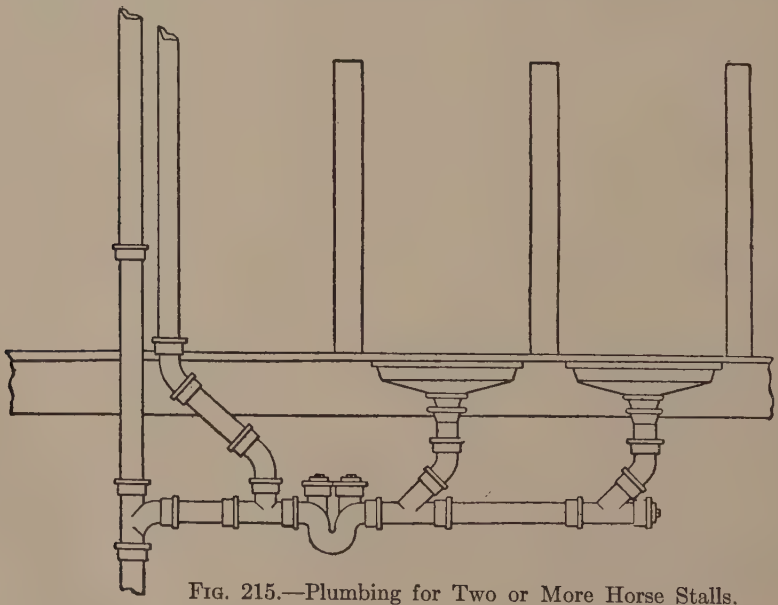


FIG. 215.—Plumbing for Two or More Horse Stalls.

method shown in Fig. 213 is generally adopted. The drip sink for such a line is usually set in the cellar, and should be trapped and vented in the same manner as any kitchen sink.

In addition to public buildings, such as schools, hotels, factories, etc., even stables now receive careful attention as to their sanitary arrangements, with the result that their sanitary conditions have in recent years been greatly improved. Although liable

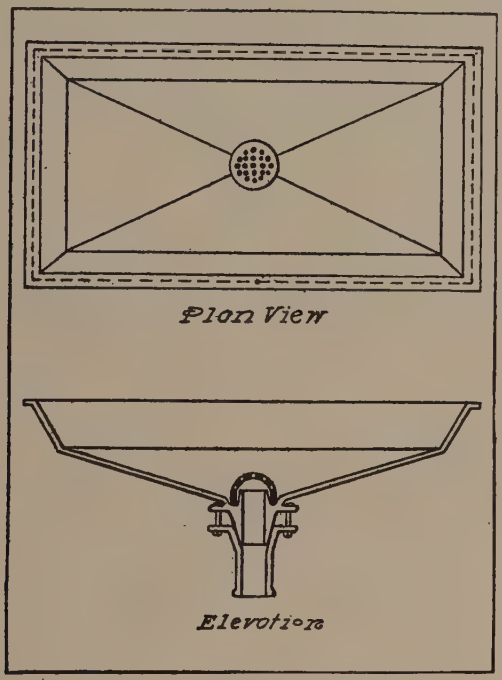


Fig. 216.—A Special Stall Drainage Sink.

to be somewhat overlooked, the plumbing of the stable should be as carefully attended to as that of the residence, for in our cities the stables of private residences and of business houses, public stables, engine-house stables, etc., are located largely in populous districts, where they may easily become public nuisances.

Naturally the most important feature in this line of work is the drainage arrangements for the horse stall, the most approved method of performing this work being shown for a single stall in Fig. 214, and for two stalls in Fig. 215.

The stall sink is shown in detail in Fig. 216, and is of cast iron, with a 2-inch outlet. The location of this drainage sink in the stall is shown in Fig. 217. For box stalls a similarly constructed square sink is used, a plan of which is given in Fig. 218.

The connections for the two stall sinks of Fig. 215 are preferable to the connections of Fig. 214. In the first place, while the outlet of the sink in Fig. 214 is connected directly into the trap, thus depriving the trap of its cleanouts, the connections as made in Fig. 215 will allow the use of two cleanouts on the trap and a third cleanout in the end of the horizontal line of waste. In

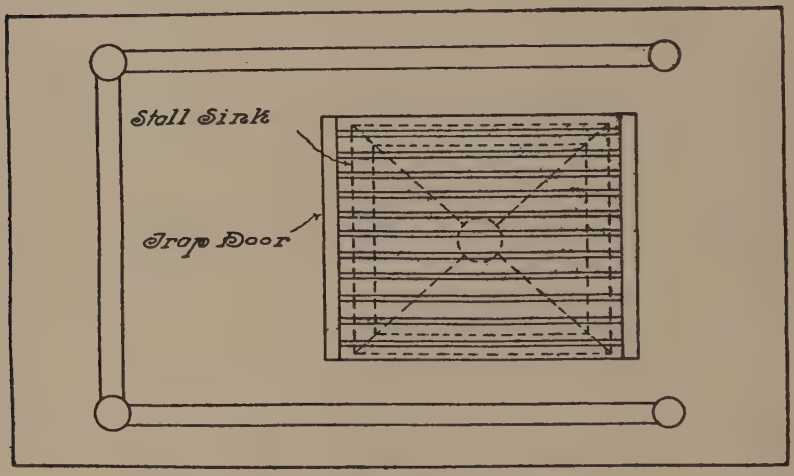


Fig. 217.—Plan of Horse Stall, Showing Sink.

order to allow two trap cleanouts to be used, the vent is connected to a tee placed next to the trap.

It is not desirable to allow one trap to serve more than two stalls, for the reason that under such conditions a long line of foul waste pipe will throw its odors out into the stable through the different stall outlets.

Floor drainage is another important feature in the plumbing of stables.

In another chapter will be found the subject of floor and yard drains. Such drains would be required in the carriage wash room, in the harness wash room, in the stable, etc. In Fig. 219 is shown an excellent form of construction for such drains. It is known

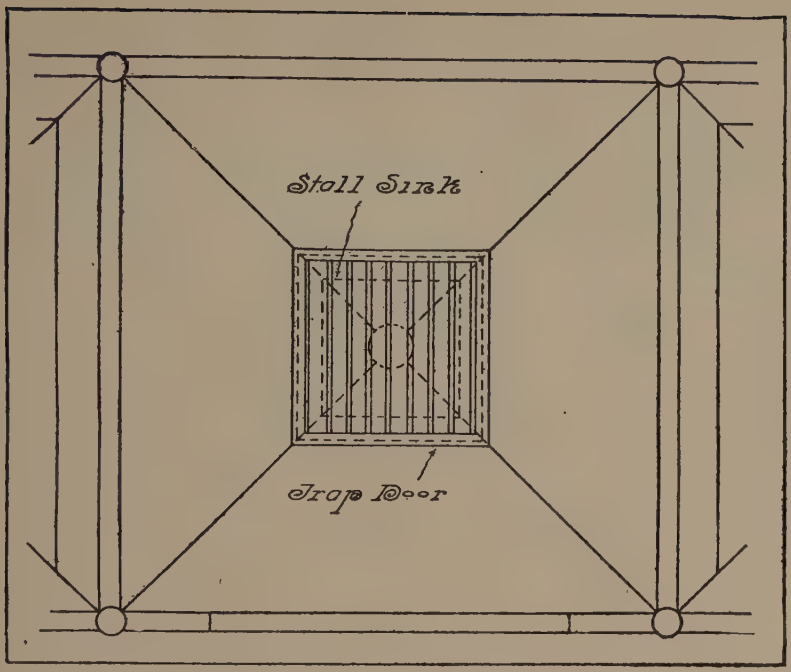


Fig. 218.—Plan of Box Stall, Showing Sink.

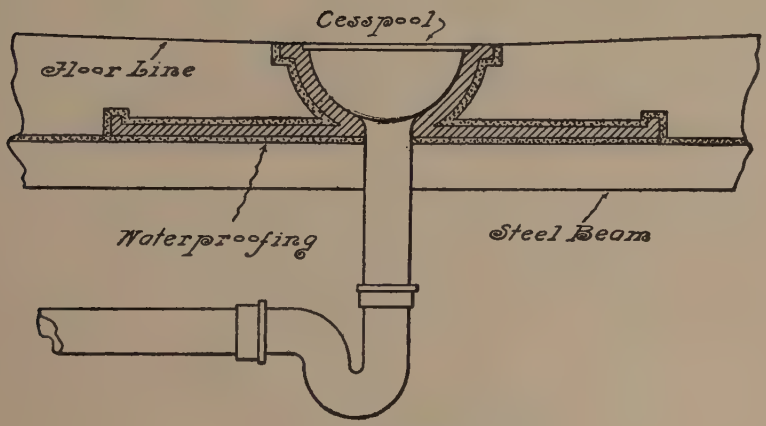


Fig. 219.—Watertight Drain.

as the F. D. C. drain. The drain is of the ordinary bell cesspool type, but cast with a broad flange, 30 inches in diameter. The drain is set in hot asphalt, which appears in Fig. 219 as the dotted section surrounding the cesspool and flange. The asphalt is waterproof, and its use does away entirely with leakage down the waste pipe, a nuisance often encountered in this work. In Fig. 220 are shown the connections for a horse trough, another necessary feature in stable plumbing. The horse trough should be provided with a standing overflow, in order to prevent the overflow of water onto the stable floor.

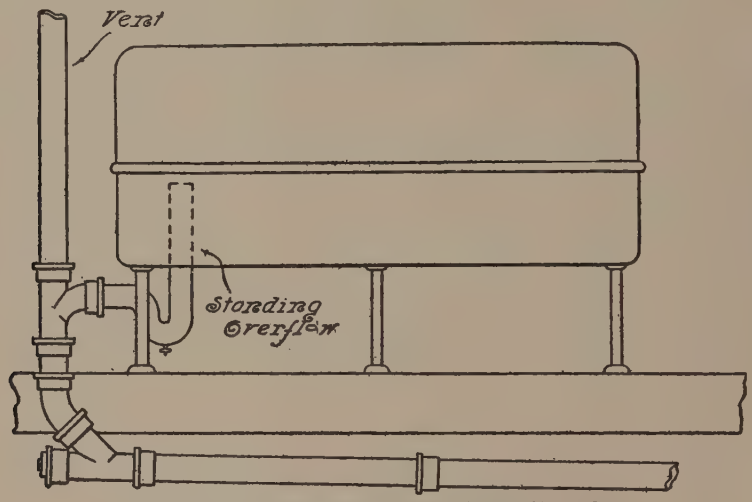


Fig. 220.—Connections for the Horse Trough.

In Fig. 221, the several connections of stable fixtures which have already been shown in detail, are assembled in one illustration, which shows the plumbing for a stable occupying two floors. In large city stables several floors are often used.

In addition to the fixtures and connections shown, most well-equipped stables are provided with toilet arrangements, with bath and toilet for hostlers, etc.

Whenever such plumbing is installed in a stable, it should be put in under the same restrictions and regulations as if the same work were to be installed in a residence.

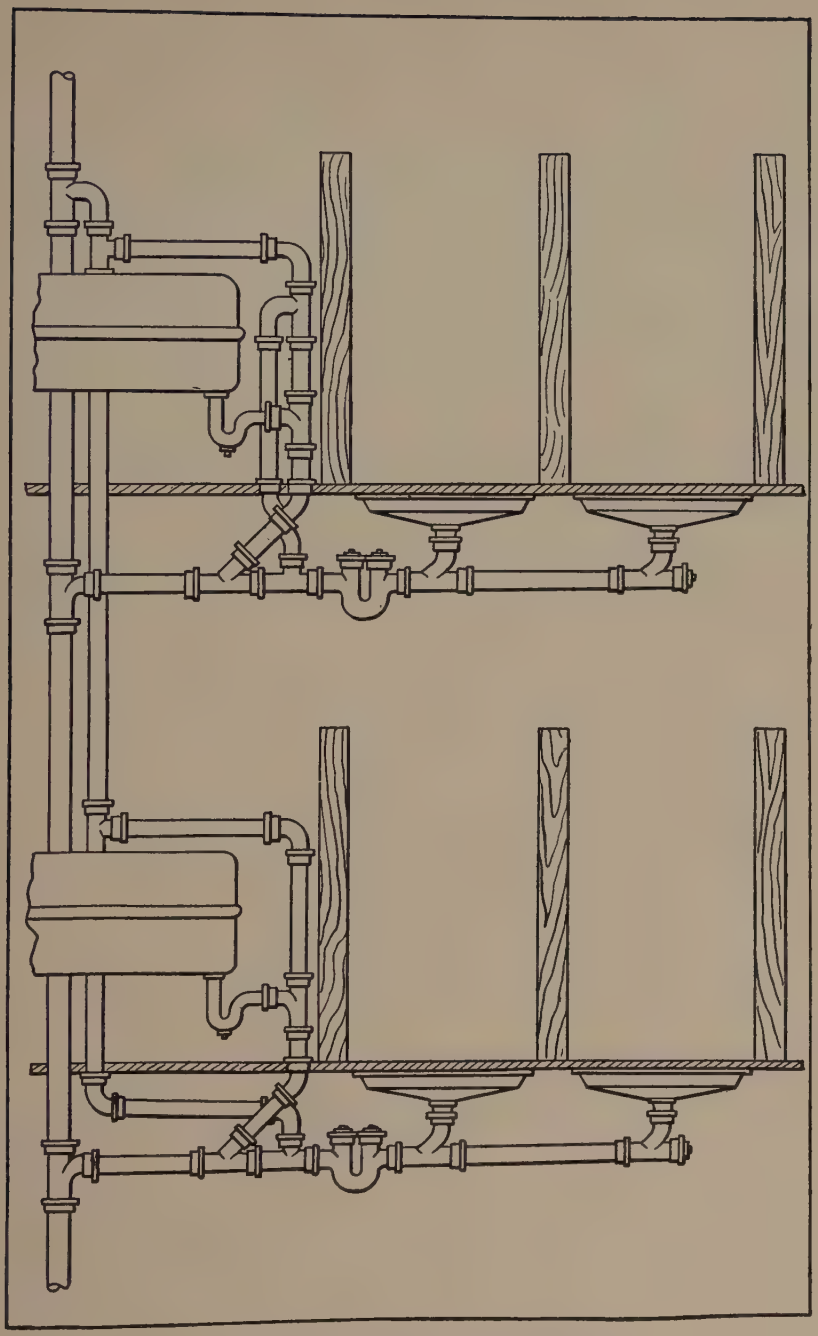


Fig. 221.—The Plumbing for a Stable.

CHAPTER XX

MODERN METHODS AND DEVICES IN COUNTRY PLUMBING

High-grade country plumbing is at the present day a far different matter than it was years ago, both as regards methods employed and apparatus used.

One of the greatest steps in advance for plumbing systems which cannot discharge their sewage into a public sewage system, is to be found in the adoption of the septic tank and automatic sewage siphon, as shown in Fig. 222.

Briefly, the septic tank comprises several chambers, including the inlet or grit chamber, one or more settling chambers, and the discharge chamber, in which the automatic sewage siphon is located.

These chambers should be air-tight and light-tight. The septic action depends upon a certain class of bacteria which exist in sewage, and act upon it in the several chambers in such a manner as to reduce in a short time all vegetable and animal matter to liquid form.

This action renders the sewage purer in each successive chamber, until the discharge chamber is reached, when it has been sufficiently freed of all solid matter, to be forced by the automatic sewage siphon out into the underground system, for final disposal into the soil. The automatic sewage siphon acts only when the sewage has risen to a certain height in the discharge chamber.

One of the greatest objections to the use of the septic tank, especially for residences, is that considerable expense is attached to its construction. With the idea of obviating this feature, there has been placed on the market, siphoning apparatus and necessary fittings for use in connection with large sizes of glazed sewer pipe and fittings used to form the several chambers of the septic tank, as shown in Fig. 223. Twenty-four-inch pipe and fittings are gen-

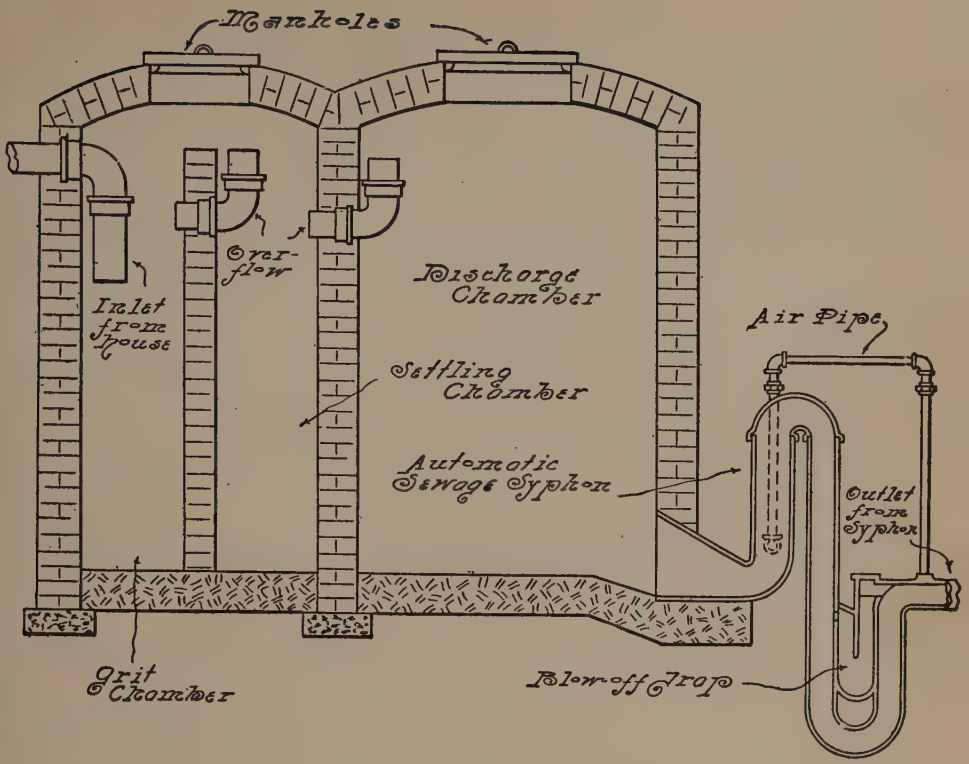
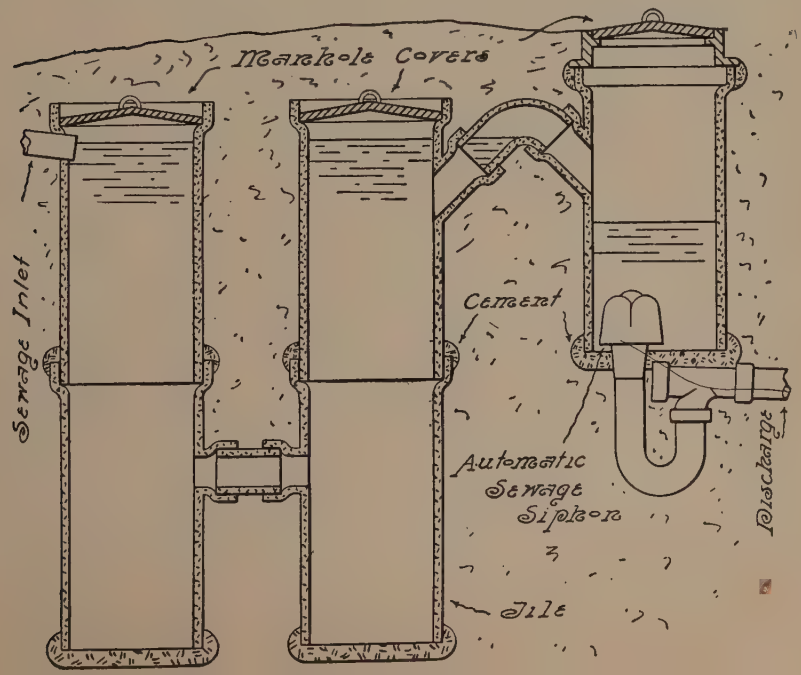


FIG. 222.—Septic Tank and Automatic Sewage Siphon.



erally used for this purpose. It will be seen that for small work, such as for most residences, the use of this material will save a large amount of expense that would otherwise be entailed for brick work, etc., and the pipe can usually be bought of local firms.

The use of septic tanks may be very much extended, to handle large bodies of sewage, by the use of two or more automatic siphons, as illustrated in Fig. 224. The outlet connections of such siphons are made in such a manner that the discharge chamber of the septic tank may empty first into one and then into another of

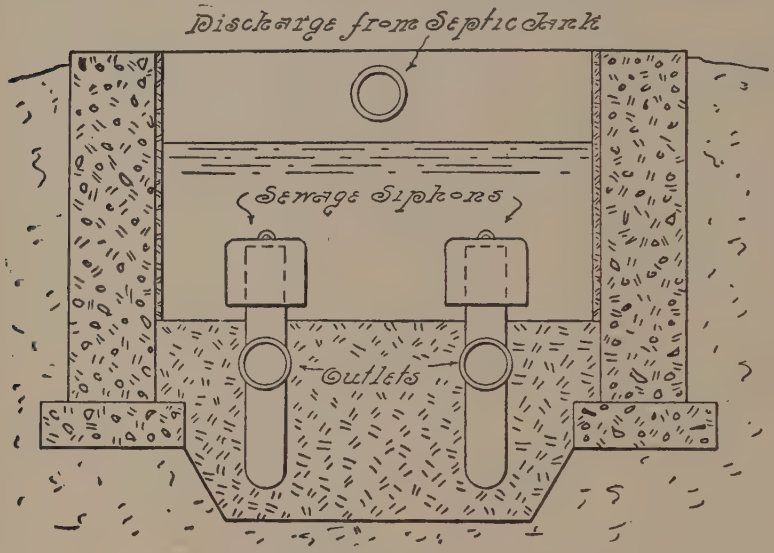


Fig. 224.—Sewage Siphons for Large Work.

several lines of underground pipe or into several different filter beds. In order to secure continuous and efficient filtration, it is always necessary to give the filtering material periods of inaction, so that oxygen may have an opportunity to pass into it, to insure the action of the bacteria. The intermittent working of these multiple siphons allows this advantage to be gained.

The sewage siphon is also used to advantage in the intermittent flushing of sewers, but as that subject is one with which the plumber would scarcely have to deal, it is hardly necessary to consider it.

The country districts have without doubt gained fully as much

from improved methods and apparatus for procuring water supply, as from the advances made in the disposal of sewage.

One of the chief difficulties regarding country water supply, is the matter of obtaining a pressure. Until the introduction of the pneumatic system of water supply, dependence was made on the house tank for pressure. The action of the pneumatic system is

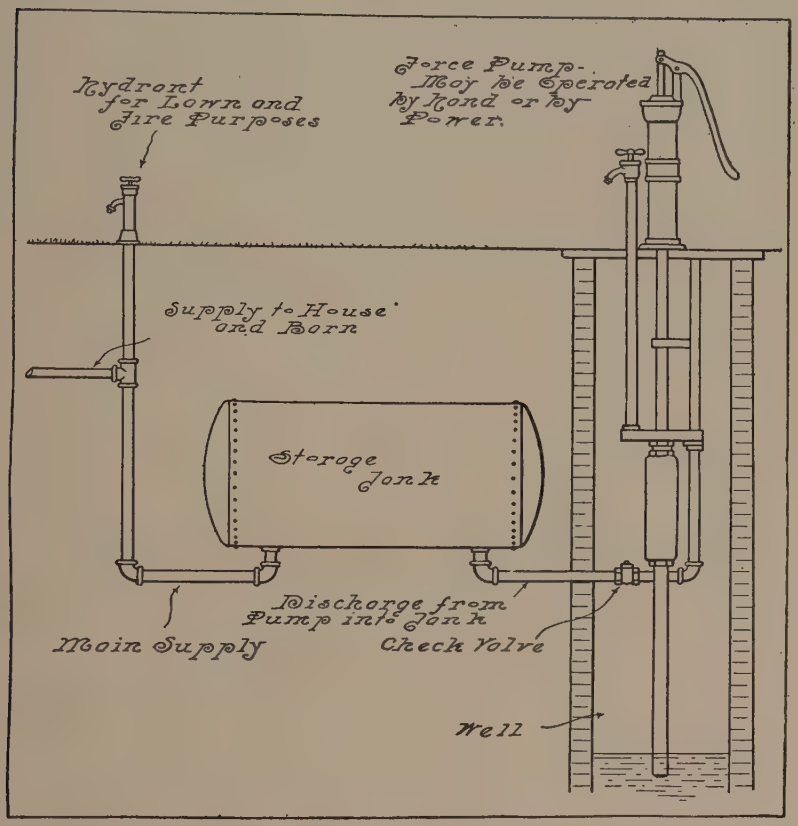

Hydrant for Lawn and Fire Purposes
Force Pump - May be Operated by Hand or by Power
Supply to House and Barn
Storage Tank
Discharge from Pump into Tank
Main Supply
Check Valve
Well

Fig. 225.—The Pneumatic System of Water Supply for Country Use.

so effective, however, and its construction and installation of so simple a nature, that the attic tank is fast being superseded, as a device that is entirely out of date. Hand or power pumping may be used in connection with it. Pressure is derived from the compressed air at the top of the storage tank. Fig. 225 shows a pneumatic supply system with the storage tank located underground

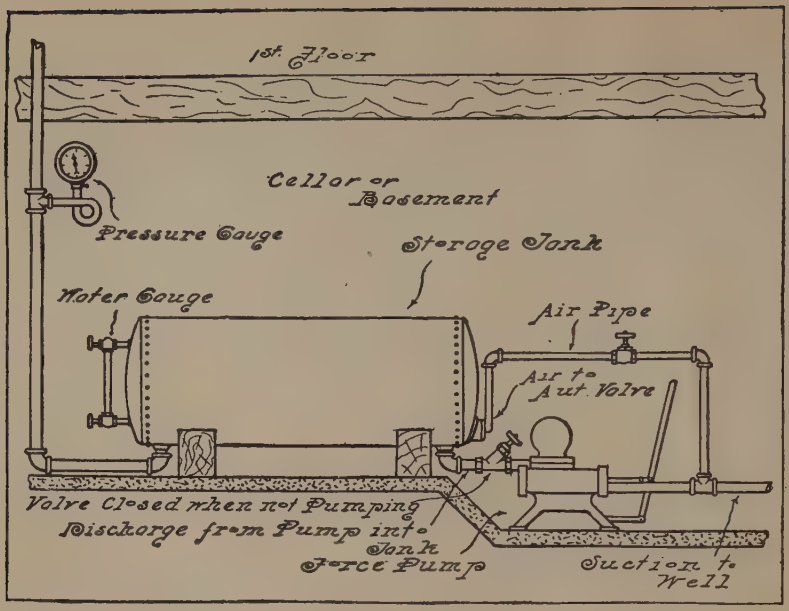


FIG. 226.—The Pneumatic System of Water Supply for Country Use.

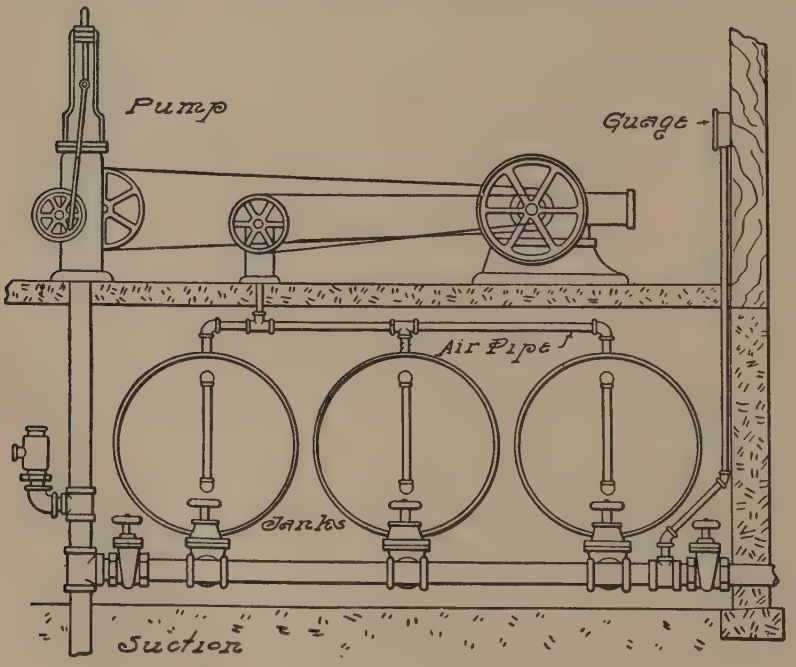


FIG. 227.—Pneumatic Public Water Supply.

and the pumping done by hand, while in Fig. 226 is seen a similar system operated by means of a power pump, in which the tank is located in the basement. This system is capable of being extended to such a degree that by means of it public pressure supplies for towns and villages of considerable size may be provided.

The general plan of such a public supply system is illustrated in Fig. 227.

From this it will be seen that the capacity of the plant may be

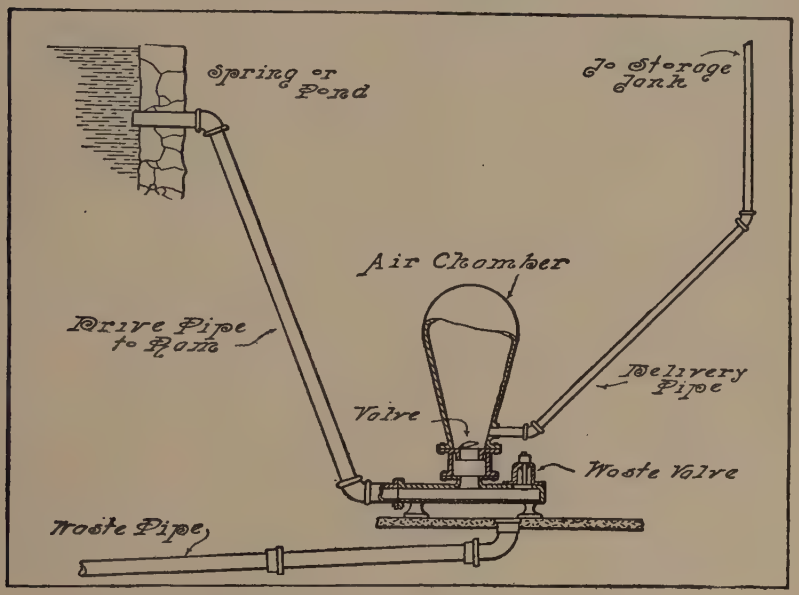


Fig. 228.—The Hydraulic Ram and Its Connection.

increased by adding additional tank capacity and greater pumping capacity.

Another piece of apparatus much used in country work, which has been greatly improved, is the hydraulic ram.

The common hydraulic ram shown in Fig. 228 is the type most generally in use. In order to insure the most efficient action of the hydraulic ram, the drive pipe, which delivers water to the ram, from the source of supply, should be as direct as possible. Occasionally, the relative locations of the ram and its source are such that it is difficult to run the drive pipe as directly as possible.

A method of surmounting this difficulty is seen in Fig. 229. This consists in the use of a standpipe, open at the top, connected with the drive pipe at or near the point where the latter changes its direction. The water will stand in this pipe when the ram has been connected, at the same level as the water in the spring. It is the standpipe, then, that operates the drive rather than the spring, its advantage being in making the drive more direct.

Under some conditions it may be more advantageous to use a tank instead of a standpipe, the result being the same.

In Fig. 230 is shown a full-page illustration of a system of

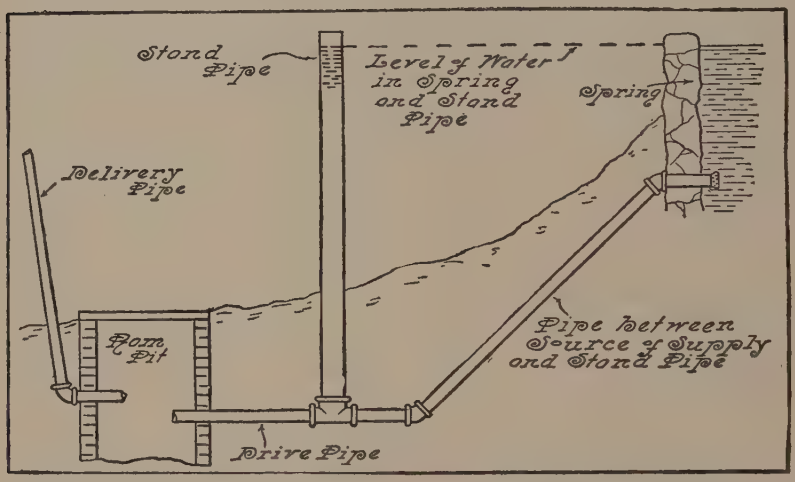


FIG. 229.—Method of Obtaining Direct Drive for Hydraulic Ram.

plumbing, drainage, and supply, for a small country home. No venting is shown, the fixtures having separate entrances into the stack, and so planned that there will be the least possible danger from siphonage.

This illustrates the common, and it may be called the old-style method of providing a pressure supply. The reader can see clearly the advantages that would be gained in this work by the use of the modern apparatus previously described.

It has not been the aim of the author in this chapter to give anything but a brief description of the several devices described and illustrated.

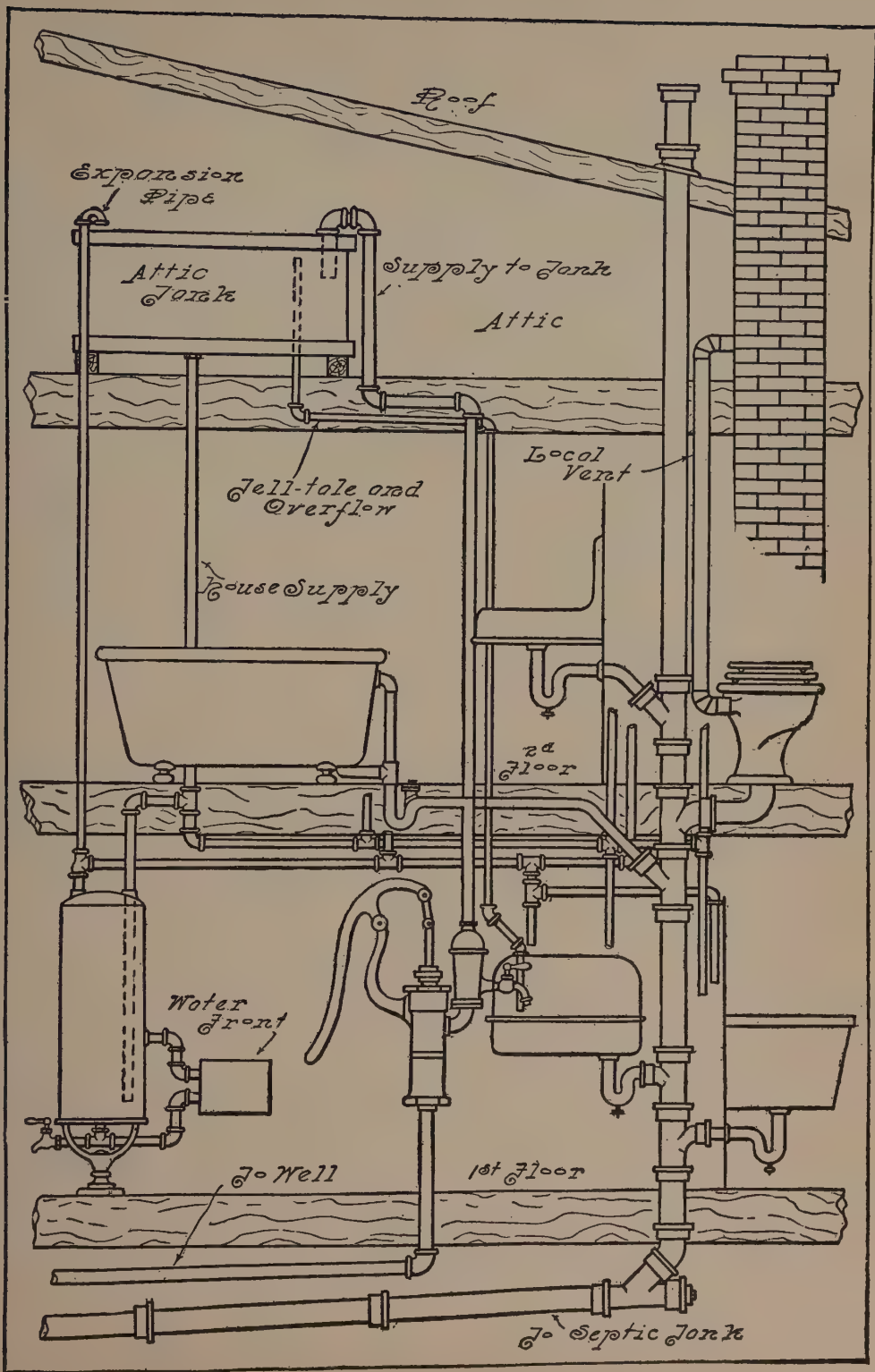


Fig. 230.—System of Drainage and Supply for a Country House.

However, a comprehensive treatment of each of these subjects, both from a theoretical and from a practical standpoint, will be found in the author's work entitled "Modern Plumbing Illustrated."

It may be added, by the way, that the subject of cesspools and the disposal of country sewage onto filter beds and into underground irrigating systems will be found elsewhere in this work.

The water lift, a device which is generally looked upon as one which has an application only to city work, is coming more and more into use in connection with country plumbing systems, and in many instances it will be found of great advantage. The action and description of the water lift will be found elsewhere in this work. Briefly, however, its action may be said to be that of the steam engine with water pressure as the motive power instead of steam pressure.

Fig. 231 shows an application of the water lift to the country plumbing system. In the absence of any street pressure, the water lift is operated by tank pressure. As the water used in running the water lift is of small amount, the demand on the tank is not great.

By means of the use of a compression tank, the lift delivers water to the fixtures under pressure. The tank operates by the compression of the air within it, and its proper position is at some point between the fixtures and the lift.

By means of the bibb on the suction pipe, the air in the tank may be renewed at any time. By opening the bibb slightly, air will be drawn in through it as the lift draws on the suction.

The cross-connection on the lift, as shown in the illustration, will allow the supply to fixtures of water from the tank whenever the well or cistern supply becomes exhausted. The use of the water lift in connection with country work is of special advantage when the supply of soft water is limited, and it is desired to use the hard well water as far as possible, or when it is desired to supply the house with soft water from cisterns and operate the lift with hard water pumped into the attic tank.

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*"Modern Plumbing Illustrated," by R. M. Starbuck, is published by The Norman W. Henley Publishing Co., 132 Nassau Street, New York. Price $4.

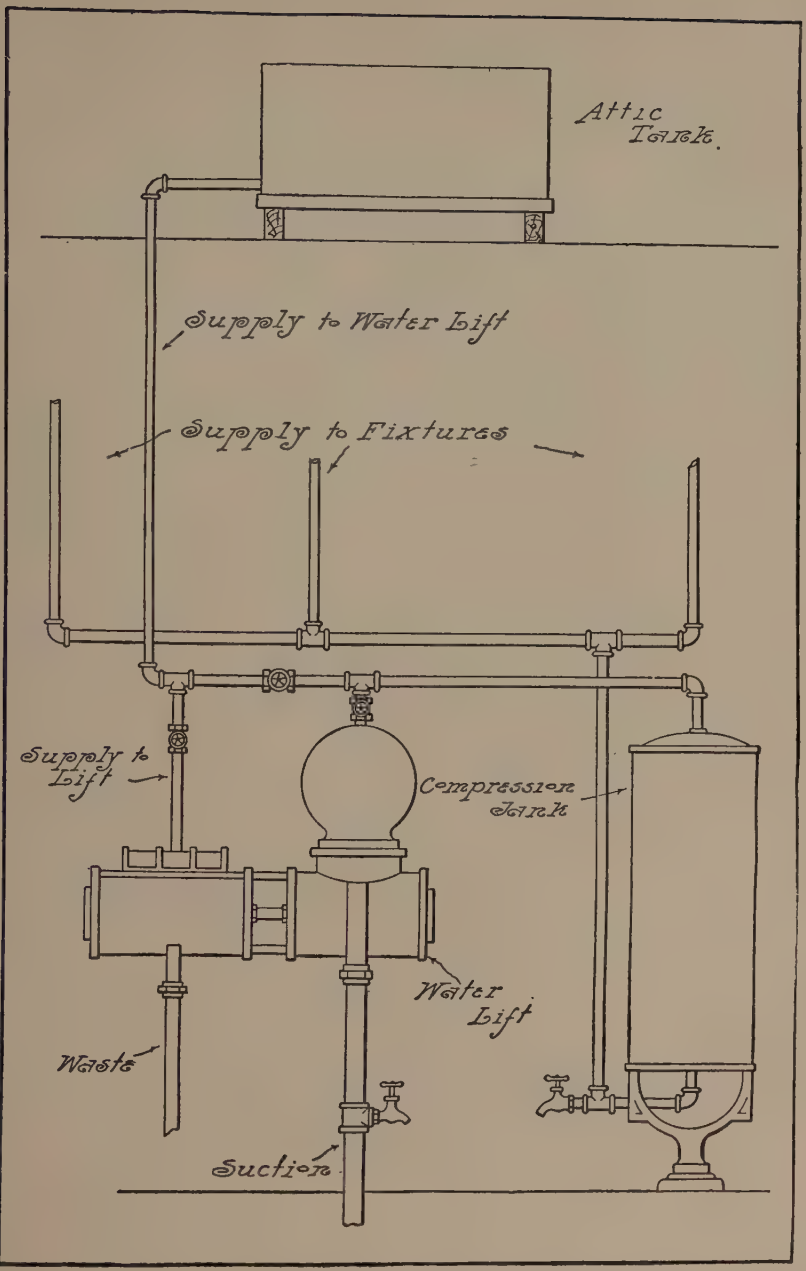


FIG. 231.—The Use of the Water Lift in Connection with the Country Plumbing System.

CHAPTER XXI

FILTRATION OF SEWAGE AND WATER SUPPLY

The subject of filtration, and the action, construction, and connection of filters should be thoroughly understood by the plumber and by the architect as well.

At first thought this subject may seem to be somewhat outside of the plumber's province, but this is not true, for it is a matter which is very often associated with the procuring of a pure water supply, and also with the proper disposal of sewage. The filtration of water supplies is a matter more especially pertaining to city work, while the filtration of sewage, as taken up in this work, applies chiefly to country work, or at least to those plumbing systems which have not the advantage of disposal into a public sewage system.

Filtration depends upon the action of certain forms of bacteria, which attack the impurities of the water or sewage, reducing them to other and purer forms. In the purification of drinking water, the action is ordinarily performed by bacteria which exist in countless numbers in sand, charcoal, stone, and various other porous substances. This form of bacteria depends entirely upon the presence of oxygen for the performance of their work. In the purification of sewage, however, it must first come under the action of an entirely different class of bacteria, which exist in vast numbers in the sewage itself, and which multiply enormously in tanks or other receptacles for sewage, when arranged in proper manner.

These bacteria have the ability to reduce animal and vegetable matter to liquids. These liquids are then further purified in the manner described above, the two purifying processes enabling the transformation of sewage into water of such purity that it may be used as drinking water with perfect safety.

In the purification of water supplies there are two methods of filtration, that by pressure and that by gravity. The former clari-

fies the water and renders it suitable for most commercial purposes and for all household purposes, except as drinking water.

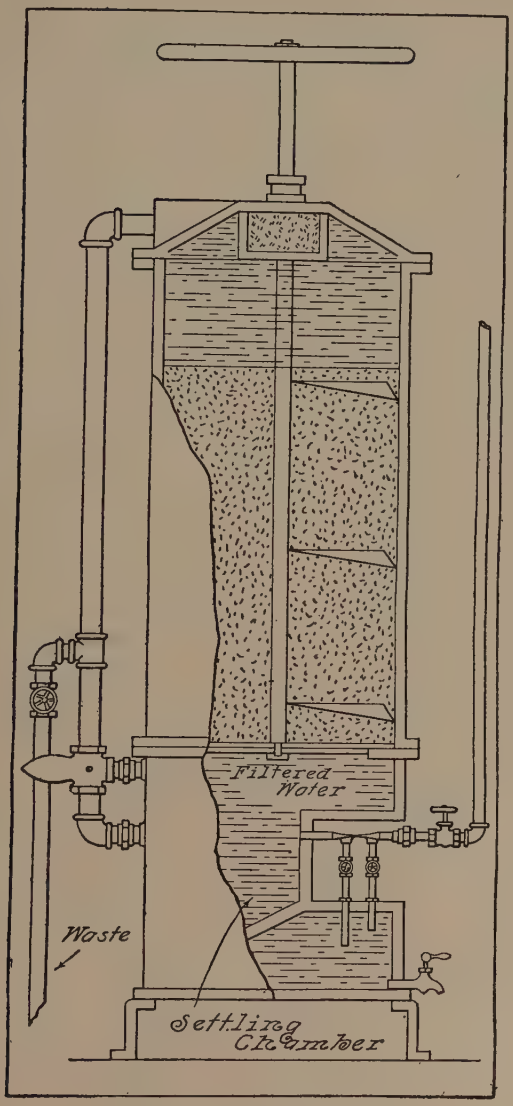


Fig. 232.—Domestic Filter.

Filters used for commercial and municipal purposes are in general of two classes, sand filters and mechanical filters, and for

domestic purposes the same classes of filters are used, constructed in somewhat modified forms.

In Fig. 232 is shown a pressure filter for domestic purposes, depending upon the use of sand. Running through the center of the cylinder is a shaft provided with projecting arms. In cleaning the filtering material, the revolving of the arms breaks up the mass, thus enabling foreign substances, sediment, etc., to free themselves, and then be washed out through the waste by a reverse flow of water.

Another form of pressure filter is to be seen in Fig. 233, bone black in this case being the filtering medium.

Fig. 234 shows still another form of pressure filter, the filtering material used being sand and charcoal, mixed in with which is a quantity of stilts of irregular shape and made of burnt fire clay. In cleaning this filter, a reverse flow of water forces these stilts through the mass of filtering material, breaking it up into small particles, and freeing foreign substances, which pass off through the waste. Thus it will be seen, that in pressure filters, of which there are a great variety on the market, various forms of filtering substances are made use of, as well as various methods of cleaning, the latter being of great importance to the proper action of any filter. The value of various filtering materials and cleaning methods, and systems in use for delivering filtered water supplies in buildings, is taken up by the author in a previous work entitled "Modern Plumbing Illustrated," on page 217.

A general idea of the connections for a pressure filter for use in residences, manufacturing plants, etc., may be obtained from Fig. 235.

While the pressure filter is of importance under many conditions, and is of special value in large city buildings, certain kinds of manufacturing establishments, etc., it does not generally purify impure water sufficiently to insure safety in its use as drinking water.

As the country grows and increases in population, the subject of obtaining pure water supplies constantly demands greater and closer attention, for as our population spreads out and occupies more territory, the danger of the contamination of once pure supplies of water continually increases.

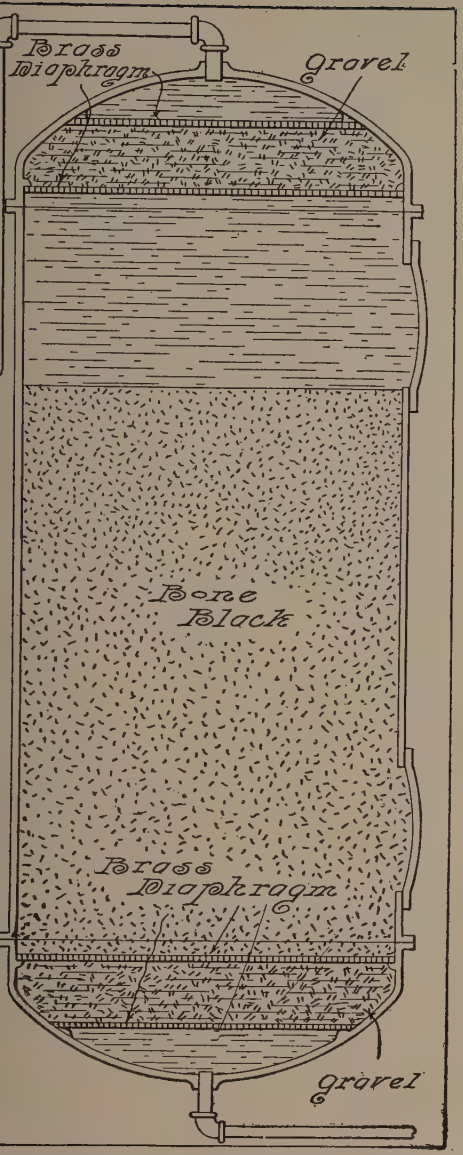


FIG. 233.—Pressure Filter; Use of Bone Black.

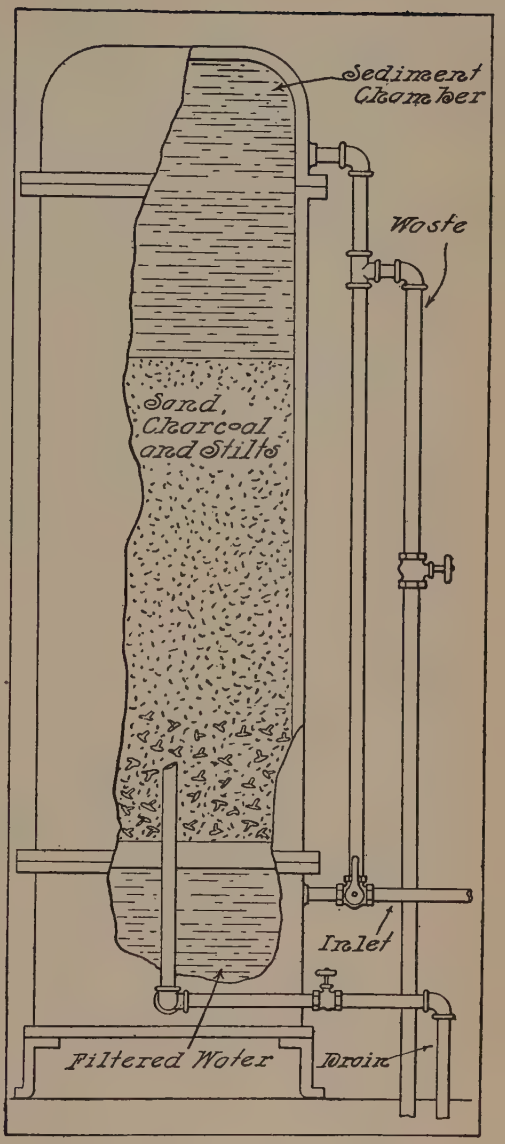


FIG. 234.—Filter for Domestic or Commercial Use.

The filtration of city water supplies by means of public filtration plants has been of untold benefit to the residents of many cities, but the danger from the use of contaminated water is not entirely overcome by this means, for inefficiency, carelessness, and

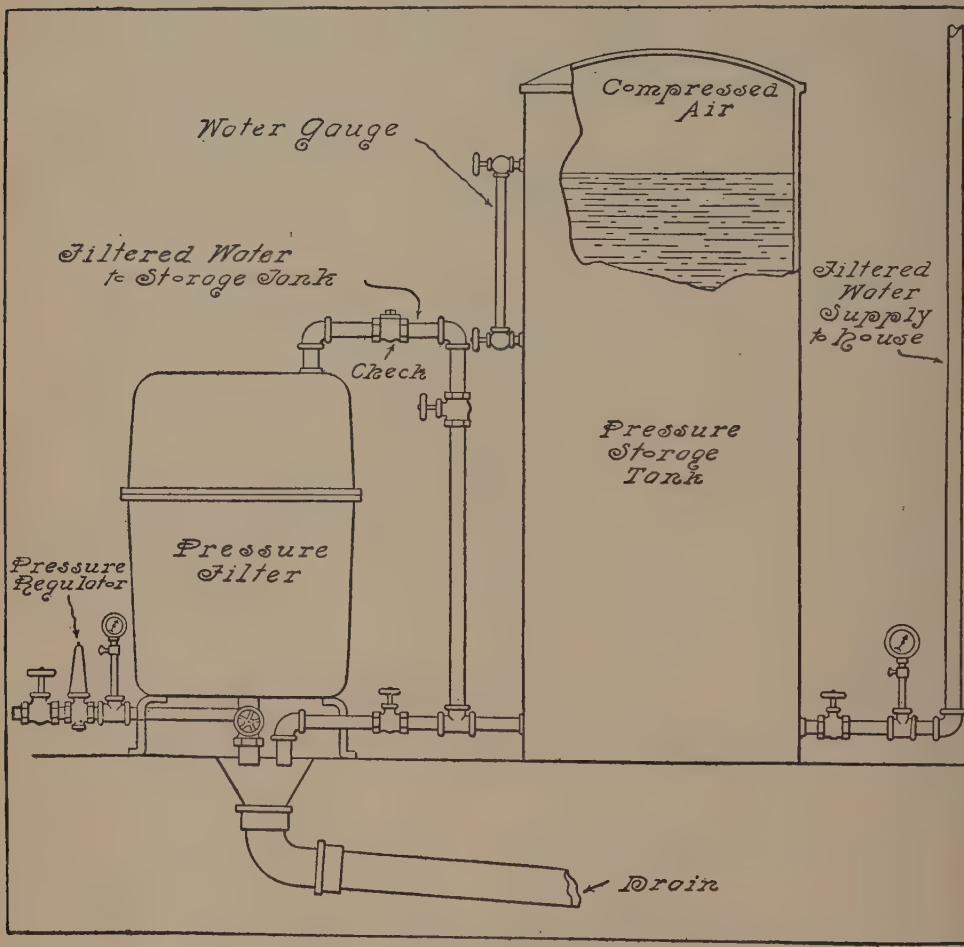


FIG. 235.—Pressure Filtering System for Residence Use, etc.

accident in the operation of such plants may easily endanger the health of an entire city.

That there is cause for extreme caution in procuring and maintaining a pure supply of water may be seen when it is considered

that many of our most dreaded diseases are often directly traceable to the use of contaminated water.

Typhoid fever and diphtheria are chief among these diseases, and the former especially is in a great majority of cases due to impurities in the water supply.

Many cases may be recalled of epidemics caused by a single case of pollution. For instance, several years ago, 1,200 cases of typhoid fever were traced to the use of an outhouse by a typhoid patient, the drainage from this house having made its way into a water course which served as the source of supply for the section in question. It may be said that even perfect filtration, that is, as near perfect as it is practicable to make it, does not entirely safeguard the users against the typhoid germ, as a small percentage, at least, always pass through the filter.

The danger, however, is reduced to a minimum when efficient filtration is provided. It may be said that distilled or boiled water is the only absolutely safe water for drinking purposes, though under most conditions neither of these processes is necessary if other proper precautions are taken.

Until recent years, it was generally considered that running water in traveling a few miles became purified through natural causes, such as oxidation, aëration, sedimentation, etc. To a certain extent this is true, but as the water travels, it is constantly taking up new impurities, so that purification in this manner should not be depended upon to any extent.

Owing to the porosity of sand and the consequent existence in it of the bacteria necessary to filtration, this is the material mostly used in filtration plants, especially for large work. That the action of filtration is dependent upon the presence of bacteria, is proved by the fact that whenever substances known to be injurious to them are allowed to enter the water, purification always ceases, either entirely or in part. The sand filter or filter bed, as it is generally known, usually consists of several beds, such as shown in Fig. 236. At the bottom of the bed, in a mass of broken stone and gravel, is laid a drain with open joints, into which the filtered water passes, and through which it is carried into a tight drain and thence to the storage point.

Above the broken stone and gravel is laid a bed of sand, which

by the way, should not be of such depth that air may not readily pass through to supply and give life to the bacteria. The impure water is discharged onto the bed and allowed to percolate through the sand, gravel, and stone, this being the action of filtration. As the water passes through and divides between the particles of filtering material, it is open to the action of the bacteria which exist there.

It will be noted that in this method of filtration, there is no pressure upon the water forcing it through the filter, but that it

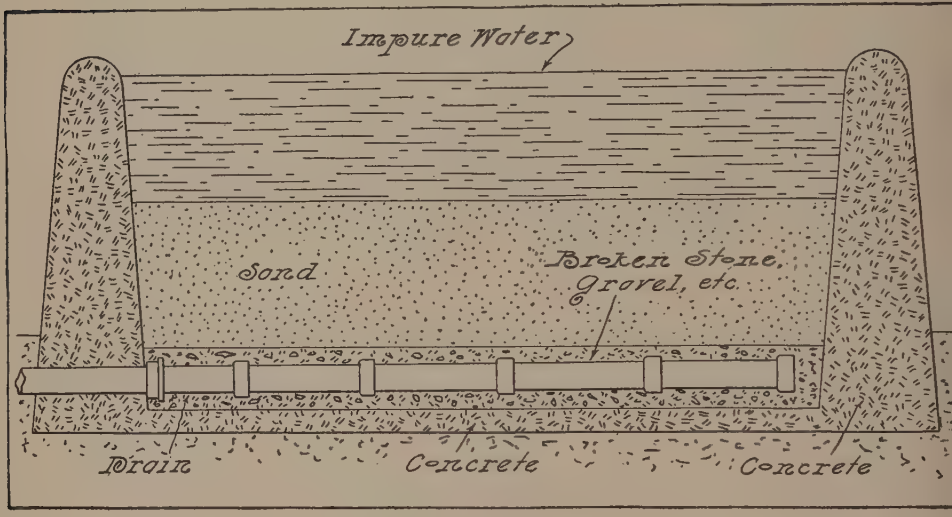


Fig. 236.—Sand Filter Bed.

acts entirely by its own gravity or weight. While the amount of water that may be filtered by this means is comparatively small when compared with the output of mechanical filters, it is nevertheless the most thorough in its work of any of the various forms of filters if properly taken care of.

Experience shows that for clarifying water supplies that are muddy and full of matter held in suspension, mechanical filtration accomplishes better work than sand filtration, and that the latter is the more efficient in the purification of water containing organic substances, such as the water of supplies contaminated by sewage.

Muddy water destroys the action of the sand filter by filling

the pores. Therefore the sand filter to be efficient, must be periodically cleaned, which in large work is accomplished by mechanical means.

In the use of sand filters, it is excellent practice to first carry the water to be purified into a settling basin or reservoir, where the action of sedimentation may first clear the water of much of its mechanical impurity before it is discharged upon the filter beds. The general arrangement of filter beds and settling basins may be seen in Fig. 237.

The gravity principle is also applied to the domestic filter and to good advantage, producing a filter which comes very much

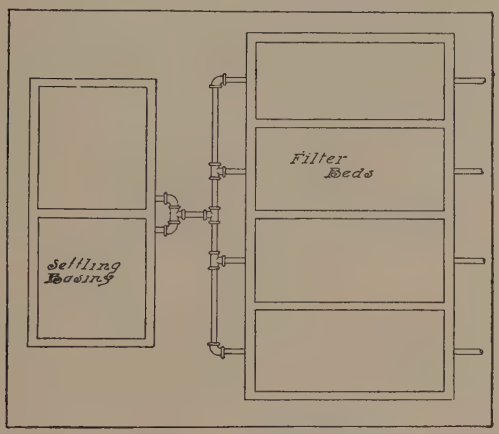


FIG. 237.—General Arrangement of Filter Beds and Settling Basins.

nearer to freeing the water of germ impurities and making it suitable for drinking purposes, than a pressure filter can possibly do.

There are several gravity filters on the market, any one of which does excellent work, so long as it is given proper attention and cleaned at frequent intervals.

The great trouble with filters used for domestic purposes, however, is that they are not properly attended to, under which conditions they may become a menace rather than the safeguard that they are intended to be.

In Fig. 238 is shown a filter working under gravity, it being one of the most popular and efficient forms of the gravity type. Water is delivered to the tank through a ball cock.

From the tank it filters through several porous porcelain tubes filled with bone black. From the tubes the filtered water enters

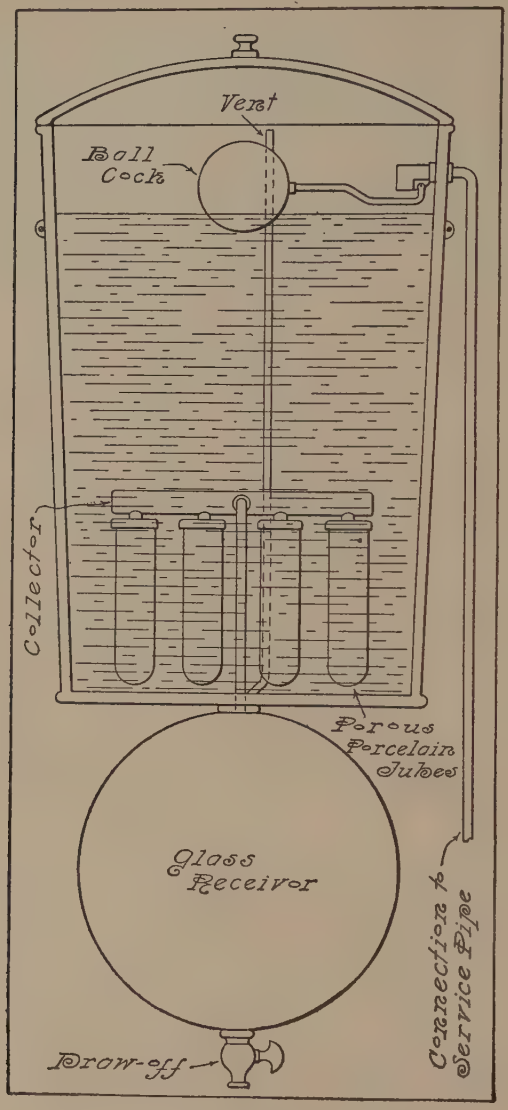


Fig. 238.—Domestic Gravity Filter.

a collector which delivers it into a glass globe, from which it may be drawn. Ice coolers of a similar nature are also made, in which

the water is filtered, but in such a way that the ice does not come in contact with it, even in its impure state. This same principle is sometimes applied to the filtration of water supplies for hotels,

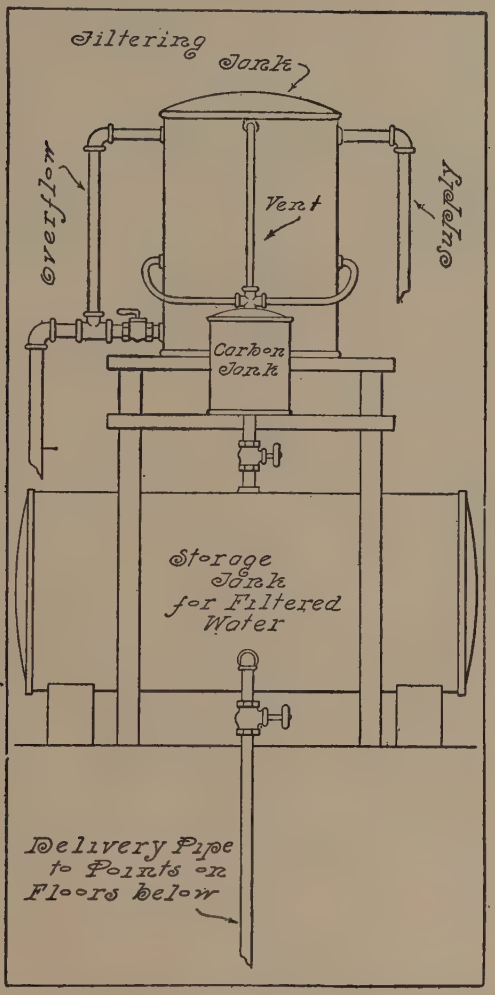


FIG. 239.—Gravity Filter for Hospitals, Hotels, Restaurants, etc.

hospitals, restaurants, etc. One method of constructing such a gravity filter is to be seen in Fig. 239, in which the tubes, which are of considerable number, are placed in the filtering tank and the filtered water carried from them to a carbon tank, where it is

filtered a second time, then delivered to a storage tank, from which it is carried to the points at which it is to be used.

The matter of filtration is of great importance also, in the dis-

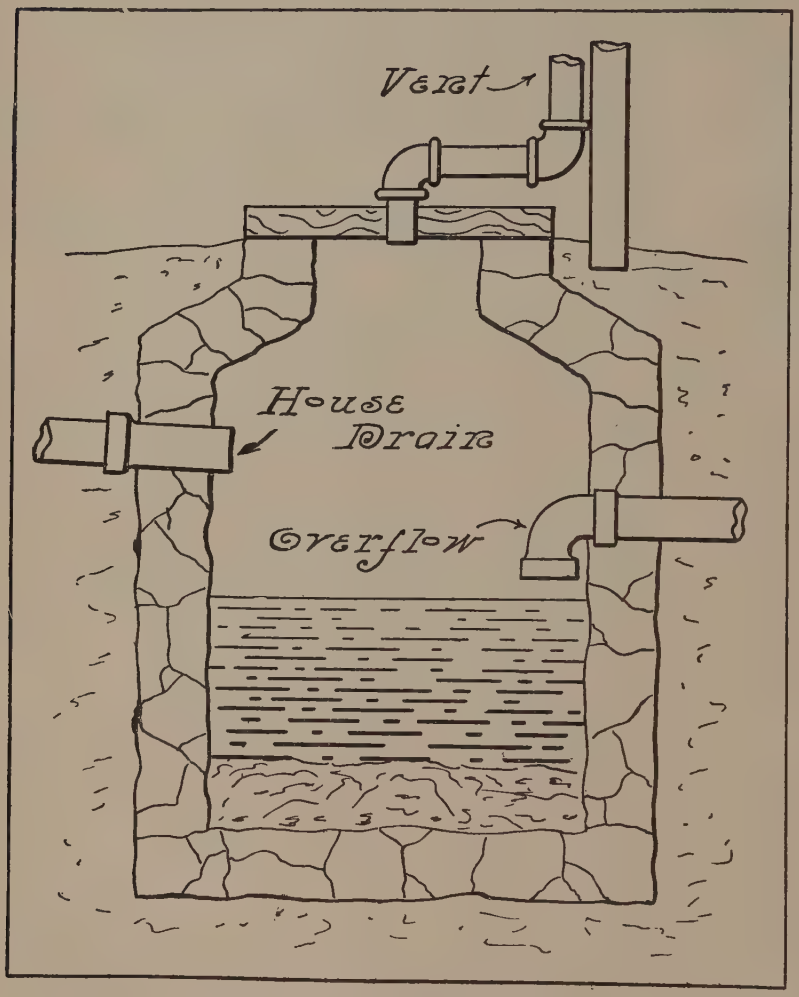


FIG. 240.—The Leeching Cesspool.

posal of sewage in country districts or wherever public sewage systems are lacking. Unless disposed of by discharging it upon the surface, sewage in country districts is more often handled by cesspools than by any other method. The common cesspool shown in

Fig. 240 is well known to the reader, while the septic cesspool of Fig. 241 may possibly be new to him. The latter while retaining the solid matter that enters it, allows the liquids to leech away into

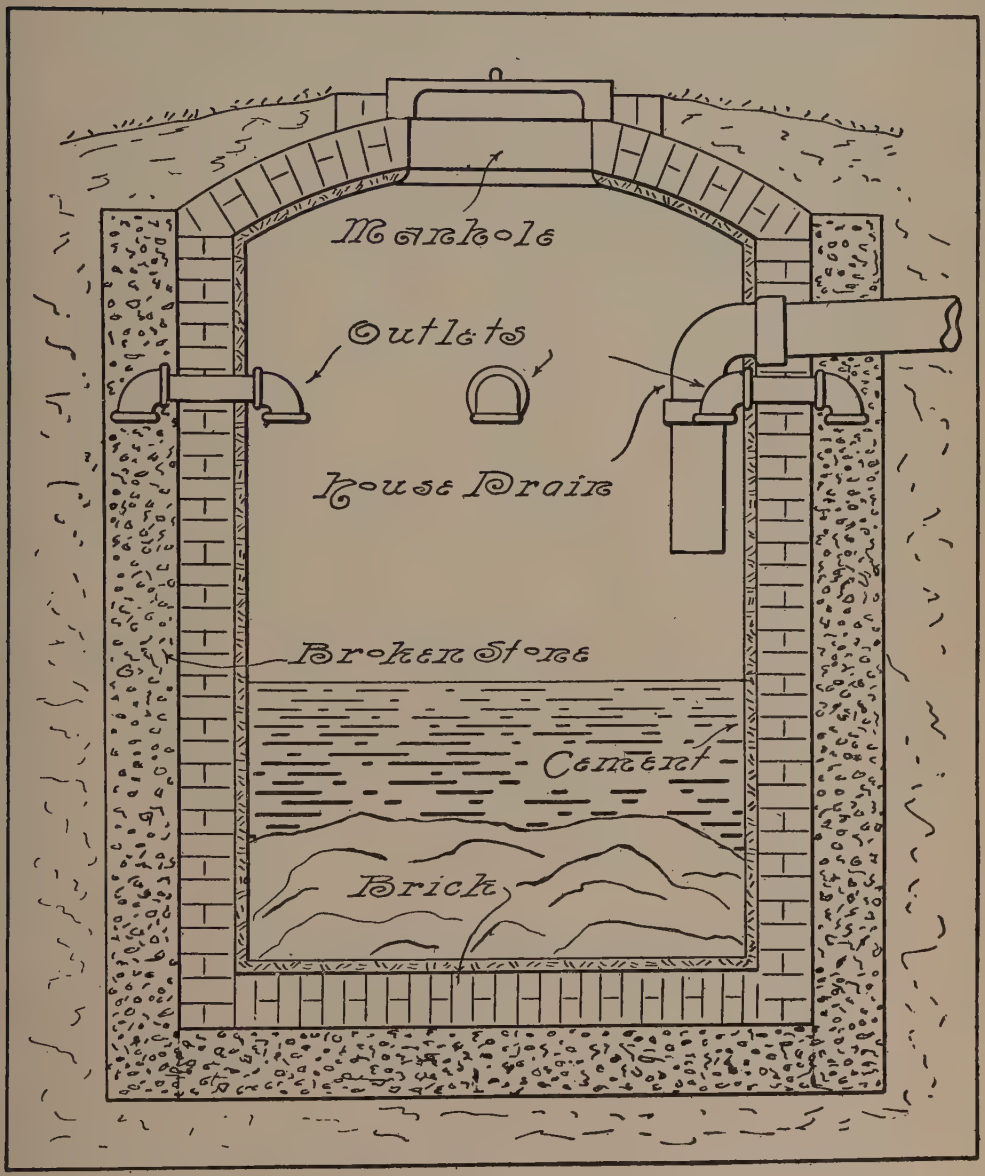


Fig. 241.—The Septic Cesspool.

the broken stone or gravel surrounding the cesspool. This particular type of cesspool is excellent when the soil is heavy or damp.

Another method of sewage disposal, in which the matter of filtration bears an important part is to be seen in Fig. 242.

Elsewhere in this work the subject of septic tanks in connection with automatic sewage siphons is taken up.

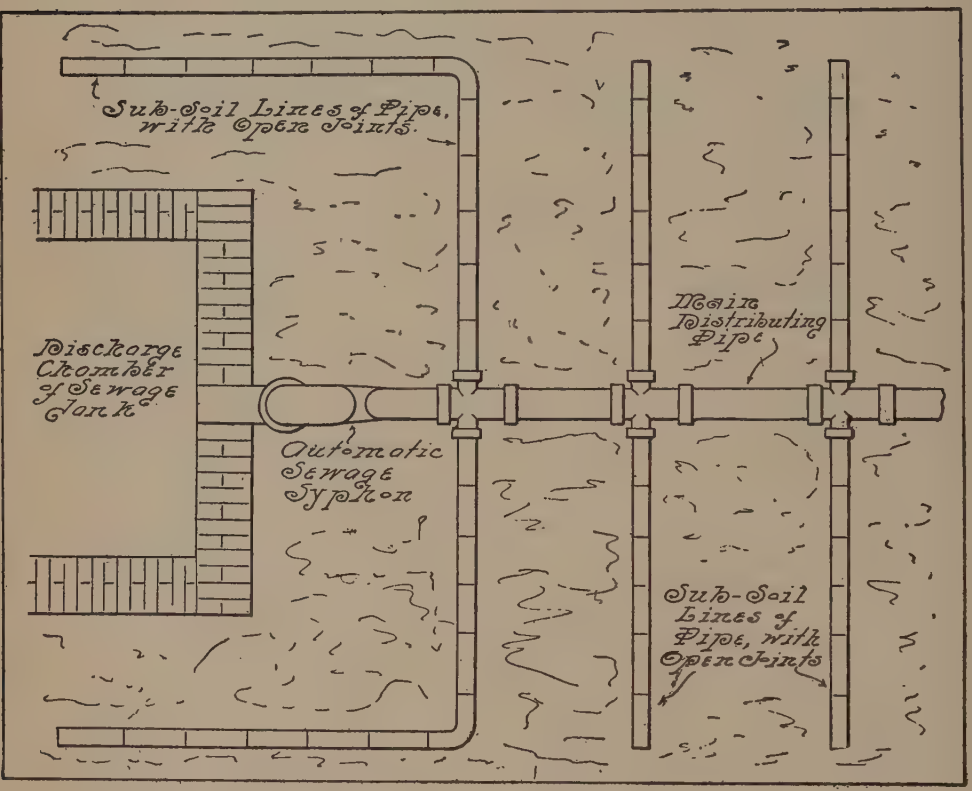

Sub-Soil Lines of Pipe, with Open Joints.
Discharge Chamber of Sewage Tank
Automatic Sewage Syphon
Main Distributing Pipe
Sub-Soil Lines of Pipe, with Open Joints

FIG. 242.—Sub-Soil System of Disposal of Sewage from Septic Tank.

These sewage siphons generally discharge the liquid sewage into an underground system of loose-jointed tile, so arranged as to allow the sewage to discharge over a large area and leech away into the surrounding soil.

The subject of cesspools, septic tanks, sewage siphons, sub-soil irrigation, and kindred subjects are treated in a comprehensive

manner by the author in his work "Modern Plumbing Illustrated."

Sometimes it happens that the soil is of such nature that the sewage cannot be disposed of underground. Under these condi-

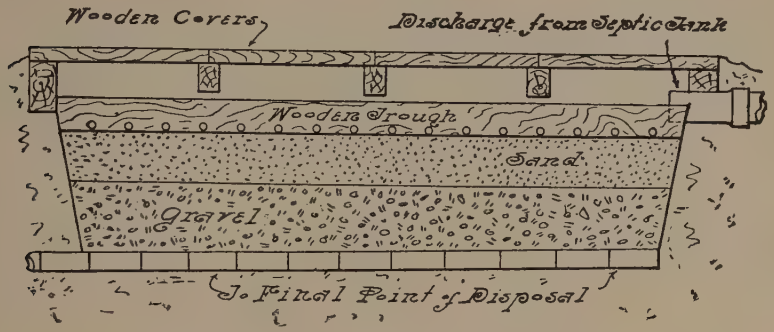


FIG. 243.—Side View of Sewage Filter Bed.

tions the sewage filter bed, shown in Figs. 243 and 244, may be used to advantage.

The partially purified waste is discharged by the automatic sewage siphon from the septic tank into wooden troughs, running the full length of the filter bed, and provided with outlets at fre-

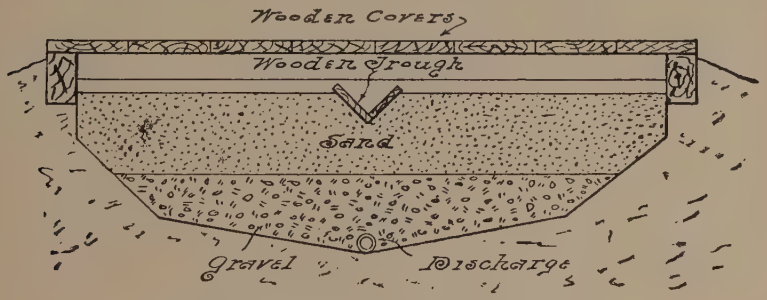


FIG. 244.—End View of Sewage Filter Bed.

quent intervals, through which the sewage escapes. When the liquids have filtered through the sand and gravel, they reach the under-drain in a pure state, and from this point may be disposed of in any way that is most practicable.

The subject of filtration should also include consideration of rain water and cistern filters. Rain water is considered the purest

natural water that we have, and in its use for household purposes, it is necessary to clarify it rather than to actually filter it, for whatever impurities it possesses are generally of a mechanical nature, and held in suspension rather than in solution. Its impurities are gathered to a very slight extent in falling, and afterwards, in its passage to cisterns, it gathers such matter as leaves, twigs, dust, etc.

In the upper illustration of Fig. 245 is shown the construction of a very successful and easily constructed filter for use in clarifying rain water before it enters the cistern.

The method of extracting the impurities of the water before it reaches the cistern, is better than the plan of filtering the water after it has reached it, as it leaves the latter in a much cleaner condition, and less frequent cleaning of the cistern becomes necessary.

In the filter referred to brick or stone is used, the entire interior being made waterproof by means of a cement lining.

A partition divides the filter into two compartments, the inlet chamber and the outlet chamber, this partition terminating sufficiently above the bottom to allow a free flow of water from one compartment to the other.

At the bottom of the inlet chamber fine gravel is filled in to a depth of 8 or 10 inches, above which is laid a layer of coarse gravel to a depth of 6 or 7 inches. Above the coarse gravel broken stone is filled in and the whole topped with a flooring of brick laid with loose joints.

The brick covering is used for holding back the coarsest substances entering with the water, such as sticks and leaves.

In the outlet chamber nothing is used but fine gravel, topped with brick, the latter being used to prevent the washing out of the gravel.

The discharge from the filter to the cistern should terminate an inch or two above the bricks.

The lower illustration in Fig. 245 shows another form of cistern filter operating on somewhat different lines.

In this case, the filter is built inside the cistern in the form of a cylindrical chamber, extending from the bottom of the cistern to a point near its top, the space at the top allowing the entrance of air. This chamber should be from 24 to 30 inches in diameter,

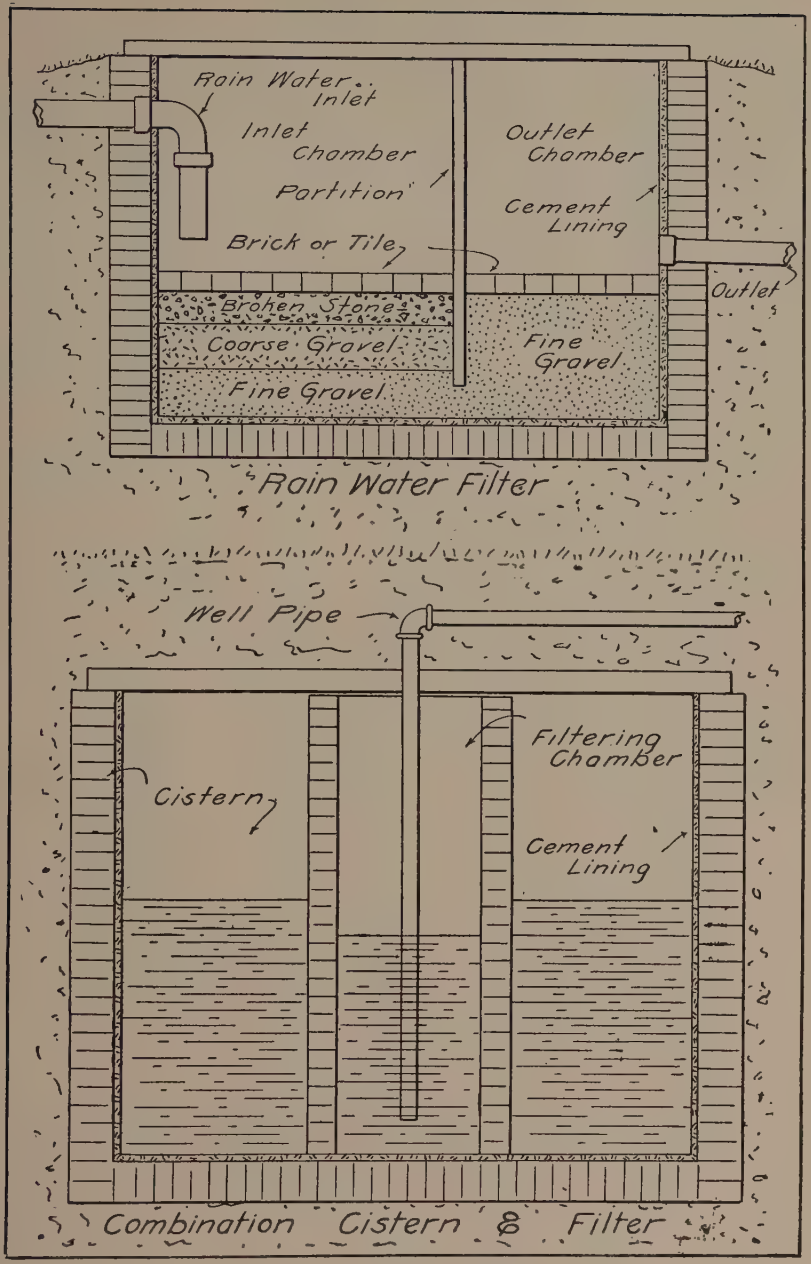


Fig. 245.—Cistern Filters.

of brick laid in Portland cement. The water in the cistern filters slowly through the brick work of the cylindrical chamber.

It is considered that filtration through stone or brick, while slow, is very thorough. The slow rate of filtration is offset by the large area of filtering surface which the brick filtering chamber presents. The cistern should be lined throughout with Portland cement. Fig. 246 gives a very good method of construction for

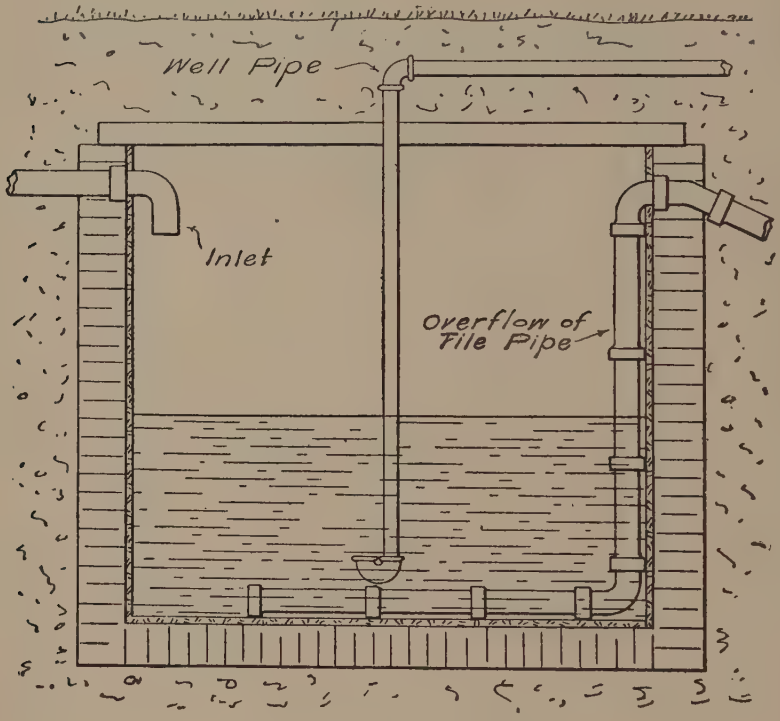


Fig. 246.—Overflow for Cistern.

a cistern overflow. The overflow is made of tile pipe, and as shown, it is laid along the bottom of the cistern and carried up to the level desired for the overflow, and there connected to the outlet. This form of overflow will carry off much of the sediment and filth accumulating in the cistern, thereby rendering it necessary to make less frequent cleanings of the cistern.

The same illustration shows a good method in connection with

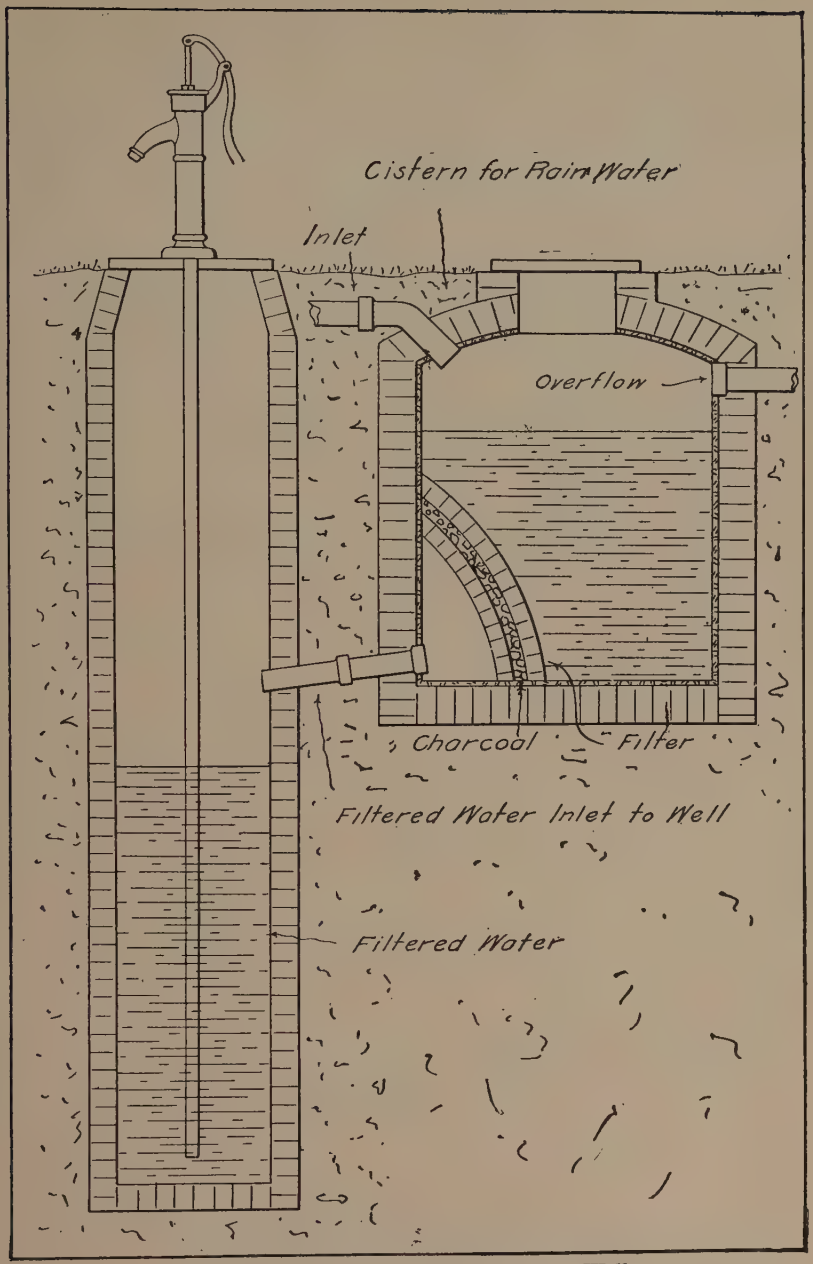


Fig. 247.—Filtered Rain Water from Well.

the well pipe of a cistern in the use of a return bend on the end of the pipe.

A straight pipe ending close to the bottom of the cistern will suck up sediment, while in the use of the return bend the suction draws the water into the pipe in a downward direction.

In Fig. 247 is shown another combination of cistern and filter which may often be used to advantage, especially in locations where rain water must be depended upon as a drinking supply at certain seasons of the year, or at all times. The illustration shows a common cistern, into which is built a filter having an arched surface, and constructed of two courses of brick, with a space of 2 or 3 inches between them. This space is filled with charcoal, which is an excellent filtering material.

In connection with the cistern and filter, a well is used, made as deep as practicable, into which the filtered water is discharged from the filtering chamber. The well is made waterproof. This method allows pure drinking water to be pumped, of the same cool temperature as ordinary well water.

CHAPTER XXII

HOT AND COLD WATER SUPPLY

The work of the plumber is divided into two distinct lines—drainage and supply.

In nearly all city work, the drainage system must be installed according to plumbing ordinances established for the purpose of securing uniformly sanitary work.

The supply system, however, in most cases is not thus protected by municipal ordinances, although in some of the more progressive cities it is now safeguarded in the same manner as the drainage system.

There was a time when nearly all supply piping was of lead. To-day, however, the use of this material has been very largely displaced by the use of brass and galvanized wrought iron. It may be stated, however, that in some sections lead pipe is still used almost entirely for supply work, generally in such cases, owing to the chemical properties of the water supply.

Some waters will attack lead pipe more seriously than wrought iron, while the reverse may be true of other waters.

Thus, in some sections galvanized piping will fill with rust and sediment in a very few years, while over the surface of lead pipe a sort of protective coating will form, which will allow its continued use for an almost unlimited length of time. The author has known of instances where wrought-iron pipes and galvanized boilers could be used only four or five years before being made entirely unfit for use, the pipes becoming almost completely filled and the boiler rusted through.

On the other hand, he has seen galvanized supply piping taken out that has been in use for twenty to thirty years, which was very nearly as clear as when first installed.

When pipe is to be laid underground, and the quality of the water will possibly permit, it should be lead rather than wrought iron, as the former has a much longer term of life when subjected to the corrosive influences incident to the moisture of the ground.

For this reason, service pipes, even though of wrought iron, are usually connected to water mains by means of lead connecting pieces. Such connections are to be seen in Fig. 248. The upper

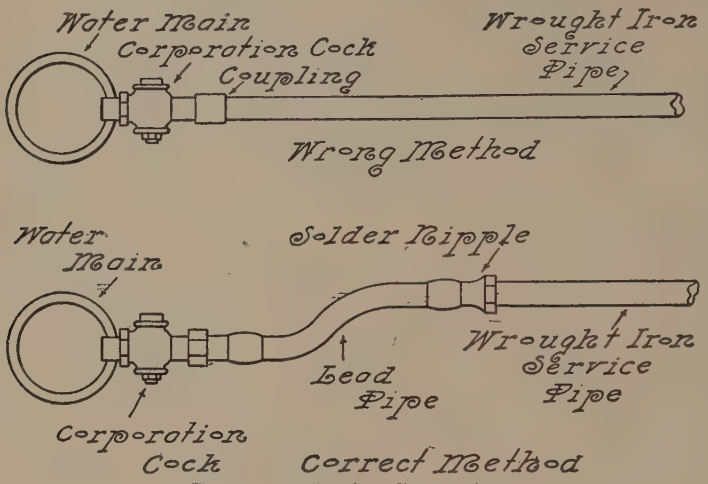


Fig. 248.—Service Connections.

connection made without lead is wrong, for it is very rigid, and liable to be broken off, whereas the lead connection will give sufficiently to take up any such strain.

From the lead connection the service pipe is carried to the

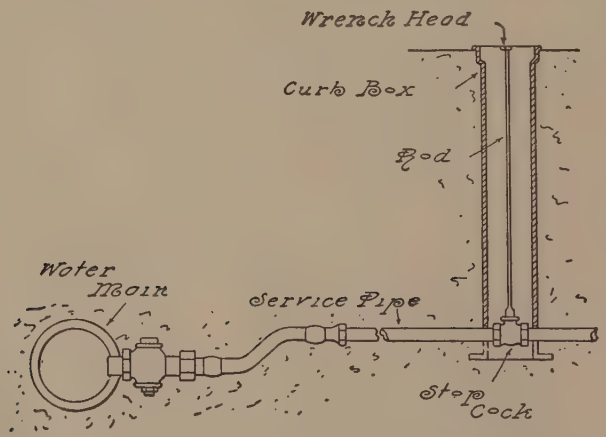


Fig. 249.—Shut-off on Service Pipe and Curb Box.

curb, where a service stopcock is usually located. It being necessary to close this stopcock from the street, a curb box, as it is called, is usually made use of, as shown in Fig. 249.

The curb box is so made that it may be varied in length to suit different depths at which the stopcock is located.

The bottom of the box is slotted so that it may set down over the pipe, resting on the earth beneath the pipe. To the stopcock is connected a rod which extends to the top of the box passing through the cover of the box and ending in a five-sided head. To open or close the cock, a socket wrench, made to fit this head, is used. A five-sided head is used instead of a square or hexagonal

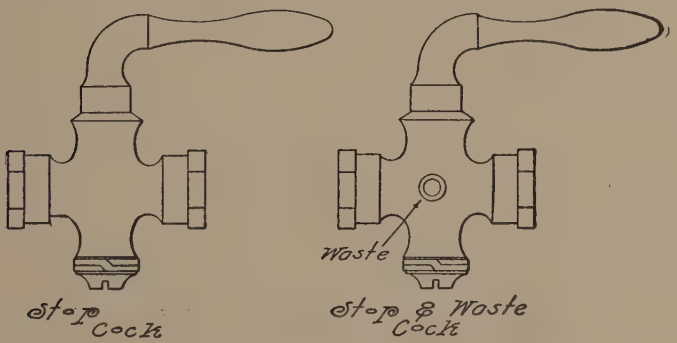


Fig. 250.—Stopcock and Stop- and Wastecock.

head, in order that only those connected with the water department and supplied with a special wrench may be able to operate the stopcock.

From the curb, the service pipe is carried through the foundation wall of the house. Just inside the foundation, the main supply pipe should be provided with a stop- and wastecock. In Fig. 250 is shown an illustration of the plain stopcock, also an illustration of the stop- and wastecock.

In the latter a small round waste opening will be observed. When the handle is turned to close this cock, the water in the piping, which is shut off by the closing of the cock, wastes out through the waste opening. By means of a small lead pipe, connected to the waste opening, this water may be conveyed if desired, to some open fixture, instead of being allowed to waste onto the cellar bot-

tom or into the ground. The use of the stop- and wastecock is a very important matter in many places where water, if allowed to stand in the piping, is liable to freeze and burst the pipe. For this reason, the main stopcock on a main house supply, should be a stop- and wastecock, in order that the entire supply piping may be drained, a very important matter if the house is to remain vacant during cold weather. This cock should always be placed in a position which will be easily accessible in the event of an emergency. It should also be fully protected against frost, so that the cock itself and the pipe beyond it may not freeze. In warm cellars, precautions of this nature are often unnecessary.

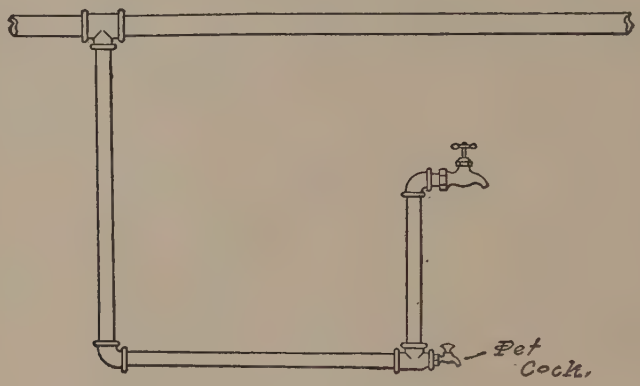


Fig. 251.—Deep Trap in Water Piping.

If necessary, however, the cock may be protected by means of boxing, hair felt, etc. The plumber in running his water piping should always be sure to run it so that no traps may be formed which will not drain off through the main stop- and wastecock.

For instance, in Fig. 251 the deep trap formed by running the branch down from the overhead line, and then up to the fixture, forms a trap which cannot be drained through the main stop- and wastecock.

If any pipe must of necessity be run in this manner, a pet cock or faucet should be placed so that when required this part of the piping may be drained. The running of pipes in this way is quite a common error, being often found on the hot-water piping especially. In order that the pipes may be thoroughly drained,

they should always pitch down in the direction of flow toward the main stop- and wastecock.

Before proceeding further with the piping inside the house, there is the hydrant to be considered, which is shown in Fig. 252. The hydrant cock or shut-off is of special design as shown, and should be of the waste pattern, in order that all water in the vertical pipe may drain into the ground when the cock is closed.

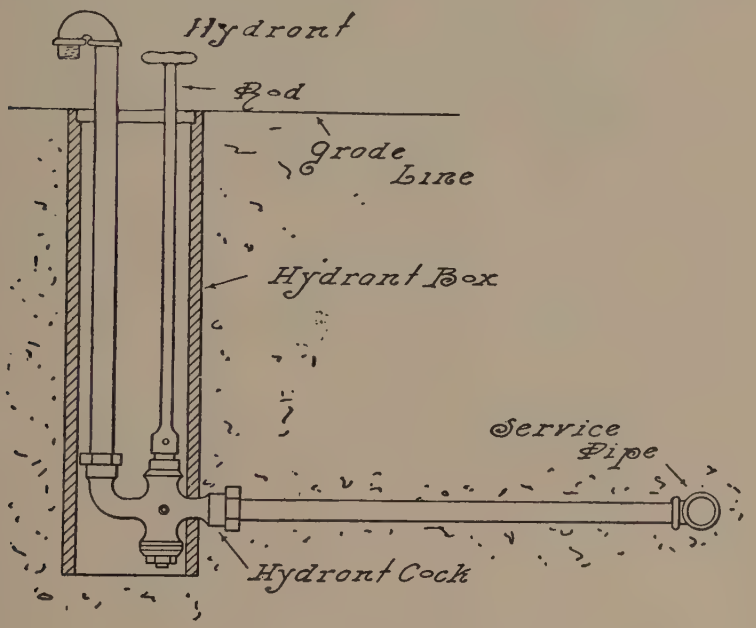


Fig. 252.—Hydrant Connections.

A rod carried to the surface is operated to open and close the hydrant cock.

On high-grade work, it is often customary to lead the main supply pipe directly to a keyboard. Such work is shown in Fig. 253. The main line of supply is run directly to the keyboard, from which every cold-water supply pipe in the house is taken. Each line is provided with a stop- and wastecock, and the waste from each cock connected into a main waste which should be carried to some open fixture into which it may drain. Laundry tubs, which are often located in the basement or cellar, are sometimes

used for this purpose. The ends of the header should be provided with tees rather than elbows, in order that any future line may be easily taken off. The end tees should be plugged.

When lead supply pipe is used, the keyboard may be made a very neat thing, as much skill may be put into its construction. The keyboard shown is designed for the cold-water supply. An

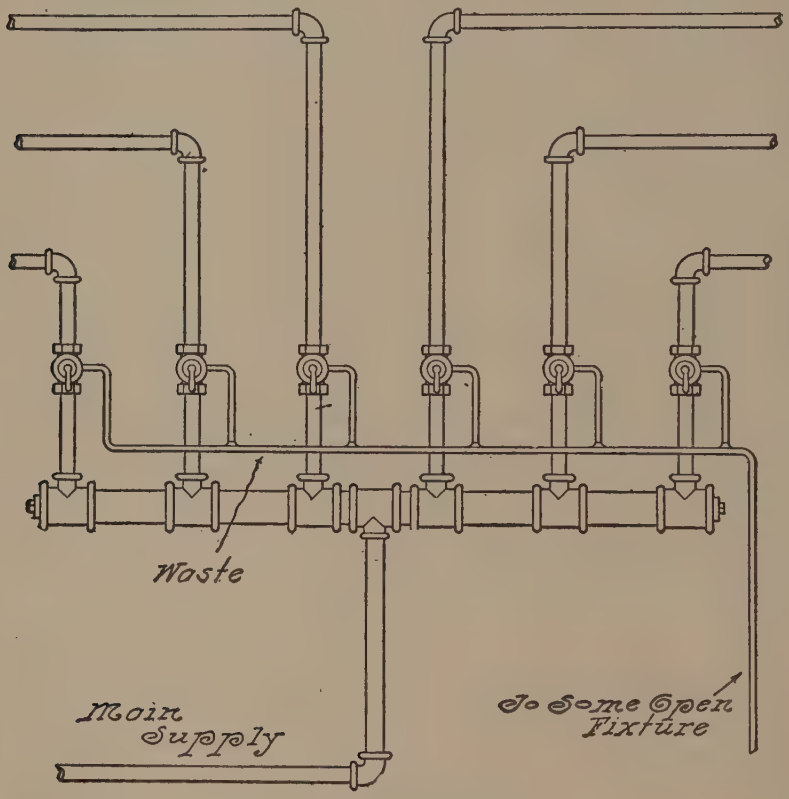


FIG. 253.—Keyboard.

additional keyboard may be used for the hot-water supplies, and a third one for the circulation or return pipes. On very nice work, polished brass supply pipe is used to a large extent. When brass is used, a very neat system can be obtained by the use of keyboards and by bending the pipe instead of using elbows and offsets. When a header is used for the hot-water pipes, the hot-water pipe from

the boiler is carried direct to the keyboard, and from that point delivered to the several lines. When a circulation or return header is used, it should be connected into the return opening of the range or heater. In order to derive full benefit from the use of the keyboard, each valve should be tagged with the fixtures and room that it supplies. Very neat nickel-plated tags, with the proper words stamped on them, are now made for this special purpose.

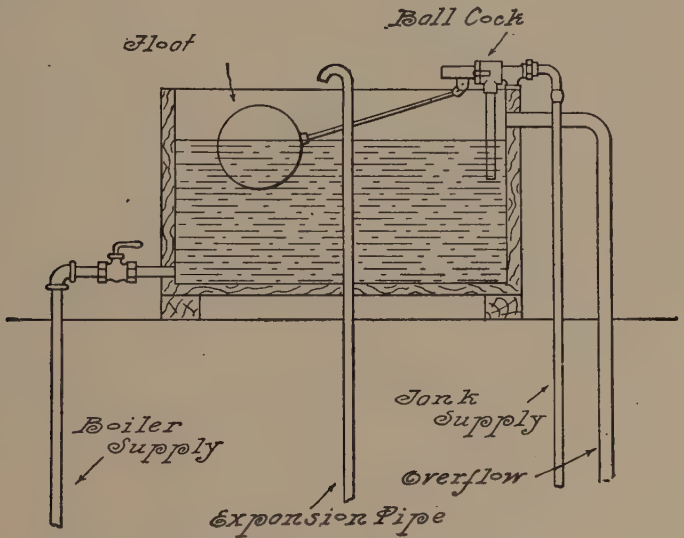


Fig. 254.—Attic Tank and Connections.

Keyboards make the work very systematic, and rob the supply of much of its mystery to the inmates. Whenever any defect or trouble with the piping arises, they may go at once to the keyboard and shut off the proper valve, avoiding the loss of time in hunting for the proper valve which is necessary in ordinary work. The loss of this time in the event of a serious break, often means great damage to the property from escaping water. Keyboard work is necessarily somewhat more expensive than ordinary work, but its value should commend it to much greater use than it has. If the keyboard is not used and the tank system of supply is used, the supply should be run to the attic tank, which with its connections is shown in Fig. 254.

There are two systems of supply in common use, the pressure system and the tank system. In the pressure system, the range boiler and all fixtures are supplied with water under street pressure. In the tank system, a tank is located in the attic, above all fixtures, this tank being supplied from the house main through a ball cock.

Years ago the attic tank was of large size, and used as a storage for water, often holding several hundred gallons. From this tank the entire supply for the house was delivered, including the range boiler and all fixtures.

In the use of the present tank, however, it is designed chiefly to supply the range boiler, the cold-water supply to fixtures being under street pressure. In the tank system as at present used, then, the hot-water supply is under tank pressure, while the cold-water supply, with the exception of the boiler, is under street pressure. As water is drawn from the hot-water piping at any fixture, an equal amount enters the attic tank through the ball cock, thus keeping a uniform supply of water in the tank.

There are certain advantages to be gained by the use of the tank system. In the first place, the pressure of water in the tank system is always uniform, whereas the street pressure varies greatly from many causes, such as a greater use of water at certain times of the day than at others. The pressure of the tank system being always uniform, the wear and tear on piping and valves is at a lower rate than in the use of the pressure system.

Lighter boilers may be used on the tank system also. The attic tank as now used is of far smaller capacity than the old-style attic storage tank. It is usually of about 50 to 60 gallons' capacity, lined with copper, and set up from the floor on pieces of joist. A very convenient size of tank is 2 feet in length, by 16 inches wide, by 15 inches deep. This is a small-sized tank, but cuts the copper to advantage.

The tank is generally supplied through a top supply ball cock. The supply to the boiler is taken from the bottom of the tank and should be provided with a stopcock close to the tank, as shown, in order that the supply to the boiler may be shut off from this point. In the case of several apartments, a single attic tank of larger size may be used, with separate supplies taken out for the different

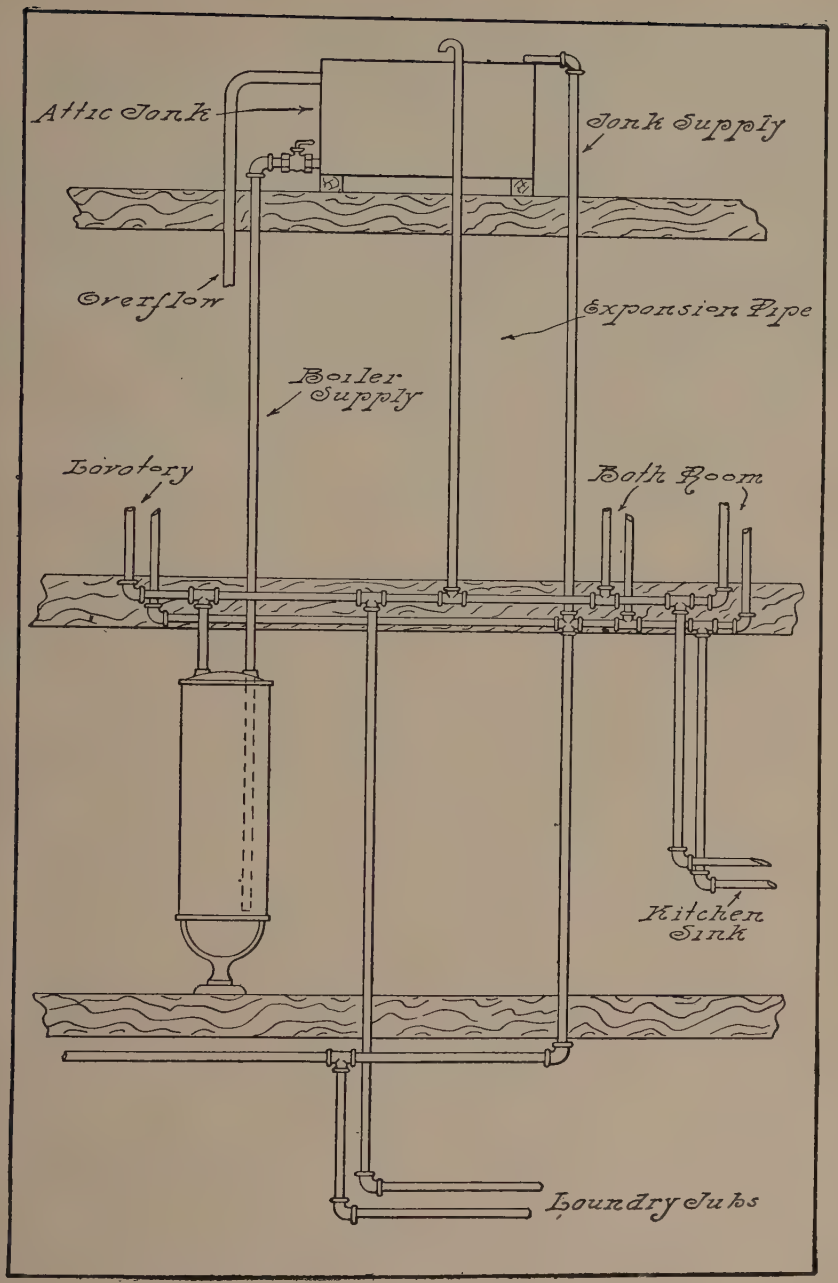


Fig. 255.—Tank System of Supply for Residence

apartments. An overflow should be run to some open fixture. It is often convenient to run this pipe into the flush tank of the water-closet in the bath room on the floor below. In the use of the pressure system no special provision need be made for expansion, as the expansion due to the hot water will be through the piping into the street main, and thence back to the reservoir. In the tank system, however, special means must be provided to take care of the expansion.

This provision consists in running a pipe from the highest point in the hot-water piping up and over the tank. Through this pipe any expansion of the hot water may vent itself into the tank. If several separate lines are fed from the same tank, a separate expansion pipe should be provided for each line. In some cases, a lead safe is placed under the attic tank, and a drip carried down, usually to the cellar or basement, to carry off any leakage from the tank. In general, however, this is not considered necessary.

In Fig. 255 is shown a tank system of supply for a residence, as ordinarily put in, and in Fig. 256 a pressure system of supply for a two-flat house.

In the pressure system, separate lines of supply are carried up to each kitchen boiler, with branches to the kitchen fixtures, and also separate lines to each bath room, each line being provided with its own stop- and wastecock.

In shutting off a supply system and allowing the water standing in the pipes to drain out through the waste of the stop- and wastecock, it will be found that by simply opening the cock, the desired result cannot be obtained. It will be necessary to open a faucet at the highest fixture in order to drain out the whole line. If a faucet on a lower floor is opened, the pipe will simply drain out up to that level. In other words, in order to allow the water to flow out of a pipe, it is necessary to have atmospheric pressure act upon the top of the column of water to be drained out. In order to completely drain the piping, it is often necessary to open faucets at certain of the fixtures. For instance, in Fig. 240, to drain the water in the pipes running to the kitchen fixtures, it will be necessary to open a faucet on these lines.

In the case of the pressure system, it is necessary to provide against the siphonage of the contents of the range boiler.

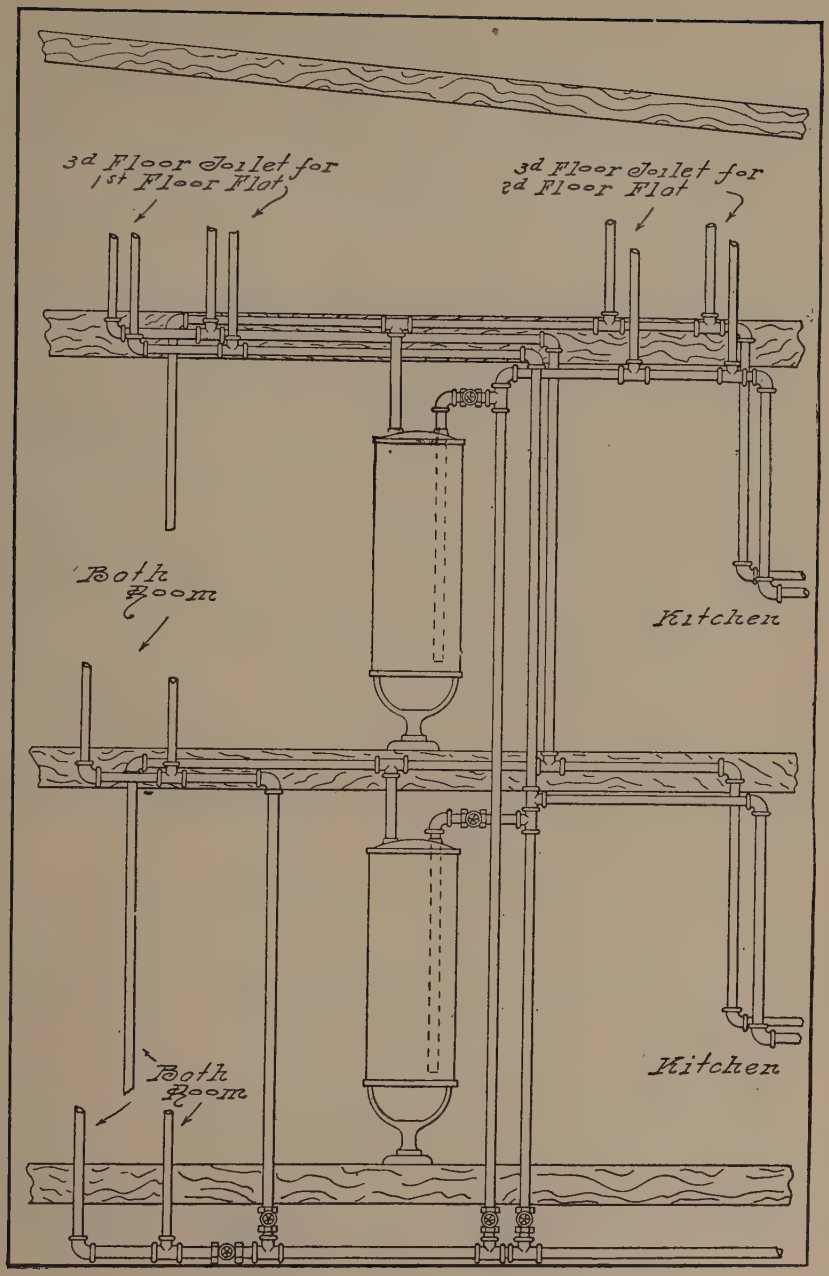


FIG. 256.—Pressure System for Two-Flat House.

The boiler tube, shown by dotted lines in Fig. 256, dips down into the boiler to a point near the bottom, the supply to the boiler being much longer than the tube, and terminating at a point much lower than the level of the boiler. Now the siphon has a short arm and a long arm, the latter ending at a point much below the short arm. Therefore it will be seen that the boiler tube and boiler supply in connection with the house main and service pipe reaching to the street main forms a perfect siphon apparatus, and a break in the house main or in the street main might allow the water in the pipe leading to the boiler to waste back and siphon out the entire contents of the boiler. If a break should occur in the night, for instance, this result might easily occur. The siphon-

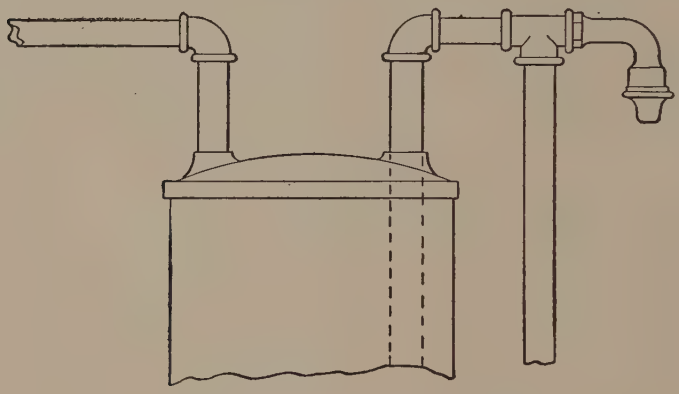


Fig. 257.—Use of the Vacuum Valve.

age of the contents of the boiler will leave a more or less perfect vacuum in the boiler, which might result in its collapse, this being especially true of certain makes of copper boilers.

In the case of the boiler supplied from the attic tank, this danger is entirely lacking, owing to the location of the source of supply above the boiler rather than below it. There are two methods of preventing the siphonage of range boilers. It may be done by drilling a hole in the boiler tube at the top of the boiler. This, however, is open to the objection that rust and sediment will in time fill the hole and render it useless for the purpose for which it is designed.

A better and surer method is shown in Fig. 257, a vacuum valve being used for the purpose of preventing siphonage. This valve should be placed on the supply to the boiler at the point where it turns from the vertical line to the boiler. It is necessary that this valve should be located at the highest point of the siphon, just as it is necessary to vent the trap from its crown, for the reason that in order to prevent the operation of the siphon, air must be admitted at its crown. The operation of the vacuum valve is the following: In the event of a break on the supply pipe, the contents of the boiler start to siphon out, owing to the creation at the top of the boiler of a partial vacuum. The instant a vacuum is created on the inner side of the vacuum valve, atmospheric pres-

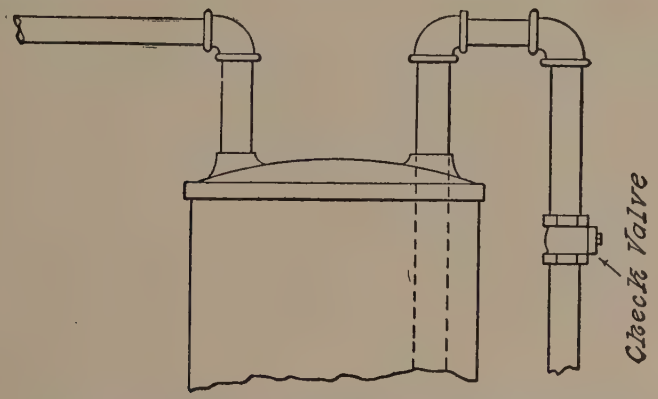


Fig. 258.—Wrong Use of Check Valve to Prevent Siphonage.

sure opens it, and air enters, thus effectually breaking the siphonic action. At other times, the pressure of the water against the valve keeps it closed.

The vacuum valve should be set to point downward, as shown, in order that any passage of water out of it may fall upon the floor rather than upon the walls or ceiling. It is a good plan to have the valve, if possible, located over the sink, so that any leakage from it may enter the sink instead of falling upon the floor. The only disadvantage in the use of the vacuum valve is that if it has not operated for a considerable length of time it may stick and refuse to work.

A dangerous method of preventing siphonage by the use of a check valve on the boiler supply is shown in Fig. 258. Ignorant workmen sometimes place it on this line, with the idea that as soon as the water in the boiler attempts to flow in the opposite direction to its natural flow, the check valve will close and prevent siphonage. It will certainly perform this duty, but in its use it acts in another way, which is very unsafe. Under normal conditions, it closes the supply pipe against expansion, and as the expansion of the boiler is naturally through the supply pipe, the use of the check valve at any point upon it prevents the natural expansion of the water as it heats. This means that the boiler is in danger of bursting.

The collapsing of range boilers and explosion of water fronts may occur from several different causes. If the connections between the range and the boiler on a pressure system should be frozen, there would be serious danger of an explosion.

If the pipes were thus frozen, expansion would be cut off and steam would be generated, resulting in the explosion of the boiler if the range fire should be started under the circumstances. If the supply to the boiler on a tank system, and the expansion pipe should be frozen, a fire built in the range would be liable to burst the boiler, especially as tank boilers are not constructed to withstand such high pressures as pressure boilers. Even though the boiler were full of water, with the boiler supply frozen, the contents of the boiler would not flow to the water front, for the reason that the frozen section of the pipe would prevent the action of atmospheric pressure from above on the water in the boiler.

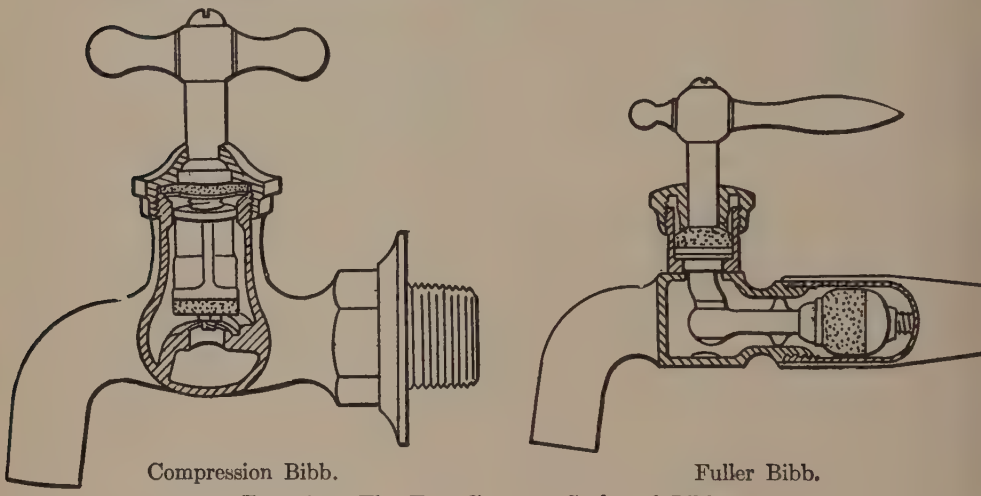
It is well in the winter season, whenever the range fire is allowed to go out at night, to open faucets before building the kitchen fire, in order to make sure that the pressure is on and no freeze-up has occurred during the night. The workman, in making repairs to the piping on pressure work, such as repairing faucets, etc., when the range fire is going, should open a hot-water faucet as soon as the boiler valve is closed, in order that any expansion may have a vent.

When the cold-water supply for any reason is shut off from the water front, and the latter becomes very hot, the moment water is allowed to enter it again steam will be generated the

instant the cold water comes in contact with the hot surface of the water front, the expansive force of the steam being very great, and in danger of bursting the water front, unless there is a vent for it. For this reason it is a dangerous matter to use valves on the range connection. They are sometimes used in multiple connections, and also sometimes on the ordinary single range connection, as a matter of convenience. It will be seen that the use of such valves would allow the water front to be cleaned out without drawing off the boiler, and in sections where the water is full of lime and the water front must be cleaned from time to time, it is very convenient to use these valves. Their use is accompanied with danger, however. For instance, the valves may be forgotten when the water front is put back, and there is liable to be enough moisture present to form steam, which without outlet is liable to be a dangerous factor. Then, again, one valve may be opened and the other through carelessness allowed to remain closed. The choking of water pipes with deposits of lime, rust, and sediment is another cause of water-front explosions.

In addition to the collapsing of boilers due to the siphonage of the contents of the boiler, there is another way in which the same result may occur. To produce a collapse of the boiler, it is necessary to create a vacuum inside it, the collapse being just opposite in action to the bursting of the boiler. Therefore, anything causing a vacuum to be formed within the boiler, will result in its collapse, if the boiler is not strong enough to withstand the strain. It is comparatively common to find the boiler collapsed, owing to the ignorance of the inmates. For instance, the supply to the boiler may be found frozen in the morning after the range fire has been started. To obtain water for the use of the household, it may be drawn out of the sediment cock. Meanwhile the water front is heating the boiler and filling it with steam. When the pipe supplying the boiler thaws out, the cold water rushes in, instantly condenses the steam, thus causing a vacuum, and the boiler collapses if not sufficiently strong to withstand the outside pressure. The collapse occurs, owing to the fact that when the vacuum exists inside there is no pressure to hold the sides of the boiler out, and they are crushed in by atmospheric pressure, which is approximately 15 lbs. to the square inch. It is very rarely that a

galvanized wrought iron boiler collapses, as it is of sufficient strength to withstand the pressure of atmosphere against a vacuum. It is not an uncommon occurrence for copper boilers, however, to suffer from this cause, unless strengthened inside. A collapsed copper boiler may often be forced back by turning on the pressure, and sometimes this can be done so effectively that almost no trace is left on the sides of the boiler of its collapse. A collapsed boiler should never be struck with a mallet or hammer, however, as the marks and indentations thus made will not be taken out when the boiler is forced back into shape. If the pressure is insufficient to



Compression Bibb. Fuller Bibb.

Fig. 259.—The Two Common Styles of Bibbs.

force the boiler into its original shape, the head must be taken off and the side forced out from the inside. The use of safety valves on range boilers is seldom seen, and their use is not necessary if the boiler is properly provided for.

There are three kinds of bibbs or faucets used in connection with the water supply: compression work, Fuller work, and self-closing work, the two first named being most common. From a glance at the compression and Fuller faucets shown in Fig. 259, it will be seen that the latter works with a cam motion, and that when the faucet is closed, it is closed very quickly, whereas, in order to close the compression faucet, the handle must be turned

several times, and a much longer time thus taken in shutting off the water. Water, as is well known, is almost incompressible, and will not compress sufficiently to take up a sudden shock. Therefore, in the use of Fuller work, much trouble is caused due to the rattling of pipes when faucets are closed, a feature entirely lacking in compression work. Therefore, even though Fuller work is more expensive than compression, and used very extensively on high-grade work, compression work will in general be found to give much more satisfactory results. Not only is the hammering of pipes disagreeable, but such action is necessarily harmful to pipes and valves.

Self-closing work closes very quickly also, and is open to the

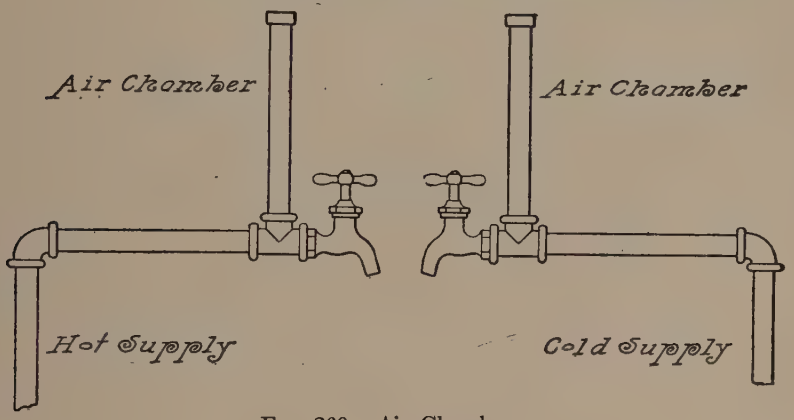


FIG. 260.—Air Chambers.

same objection as Fuller work. When the pressure of the supply is very heavy, this trouble is a serious one. The only way to proceed against the trouble is to use air chambers. Air, unlike water, is very compressible, and easily takes up the shock occasioned by the closing of valves.

In Fig. 260 is shown the customary method of providing air chambers at the different fixtures. This method consists in turning upward with the supply pipe a distance of a foot or so. Whenever either of the faucets shown in Fig. 260 is closed, or faucets or valves in other parts of the house are closed, the resulting shock is taken up in these air chambers, hammering and vibrations being thus prevented.

Sometimes air chambers are formed by continuing the supply pipe past the faucet horizontally, without turning the pipe up. The last-named method is a very poor one, however, for the water soon carries out the air with it and the air chamber becomes water-logged and absolutely useless. The air chambers shown in Fig. 260 will in time also become water-logged, and when once in this condition cannot be renewed with air by drawing off the water in the piping, as the water in the air chambers will not pass out of them, owing to the fact that there is no air pressure at their

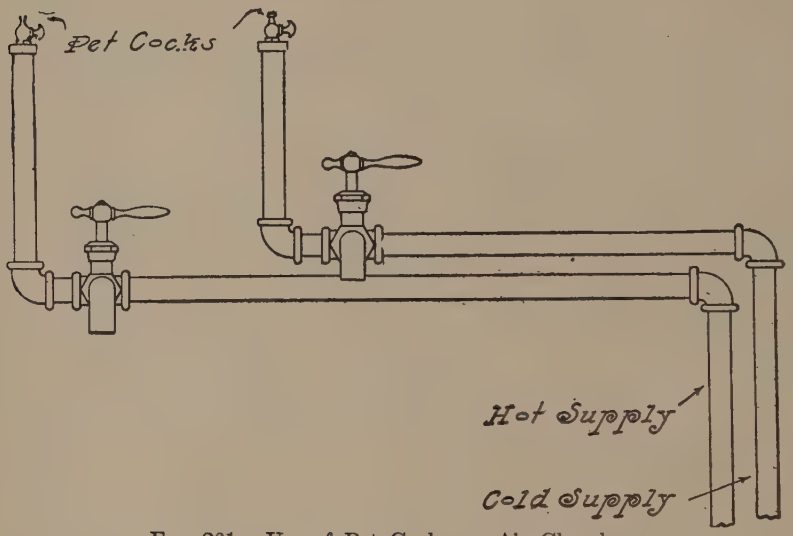


Fig. 261.—Use of Pet Cocks on Air Chambers.

upper ends to force the water out. The method shown in Fig. 260 is a very common one for providing air chambers on the supply system, but is in reality a poor method, as the water will gradually absorb the air and carry it off through the faucet in minute particles, and in time, as stated above, absolutely destroy the air chamber. The method shown in Fig. 261 would present a means of renewing the air in these air chambers, and thus overcoming the difficulty above mentioned, but is a device seldom made use of, for some unknown reason. The illustration referred to shows a pet cock used at the upper end of each air chamber. When the pipes begin to hammer, it shows that the air chambers have become

water-logged, in which event it is necessary simply to close the main stop- and wastecock, allowing the pipes to be drained. When the pressure has been shut off, open the pet cocks until the water has run out of them, when they may be again closed. In this way, by the use of pet cocks, it is an easy matter to renew the air chambers at each fixture in the house. The method is sometimes adopted of using a single large air chamber on the main supply pipe, allowing this device to perform its work for the entire house. In Fig. 262 is shown a desirable method of constructing and connecting such an air chamber. A short branch

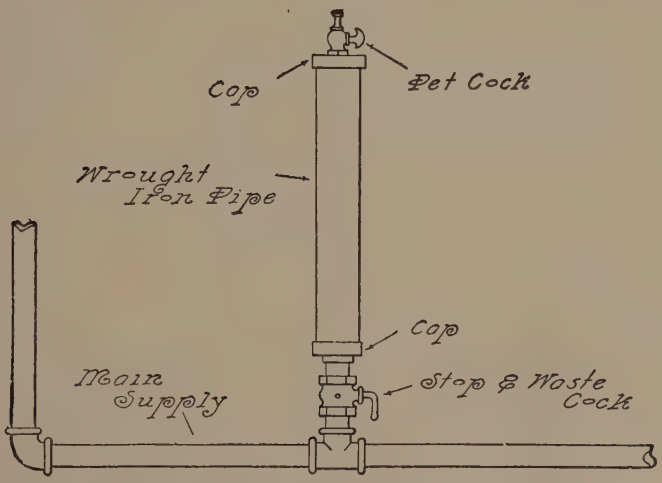


Fig. 262.—Air Chamber on Main Supply Pipe.

may be taken from the main supply, into the bottom of the pipe forming the air chamber, and between the chamber and the main, a stop- and wastecock should be placed.

The chamber may be made of 2-, 3- or 4-inch galvanized wrought-iron pipe, capped at the upper end, and tapped to receive a pet cock. The joints should be made absolutely air tight. When this air chamber becomes water-logged, it is a simple matter to close the stop- and wastecock and open the pet cock, thus allowing the water standing in it to drain out through the waste. After the chamber has been entirely drained, close the pet cock and open the stop- and wastecock, and it is again ready to perform its

duties. If the stop- and wastecock is not used on the branch to the air chamber, it will be necessary in draining it to close the stop- and wastecock on the main supply, thus shutting off the entire building.

On many supply systems, the use of a water-pressure regulator is accompanied by good results. It makes the valves and pipes safe from the dangers due to high pressure, prevents hammering and vibrations of pipes, and avoids the splashing of water when drawn under high pressure. When used on pressure work a relief valve attached, allows for the expansion, and in the case of a

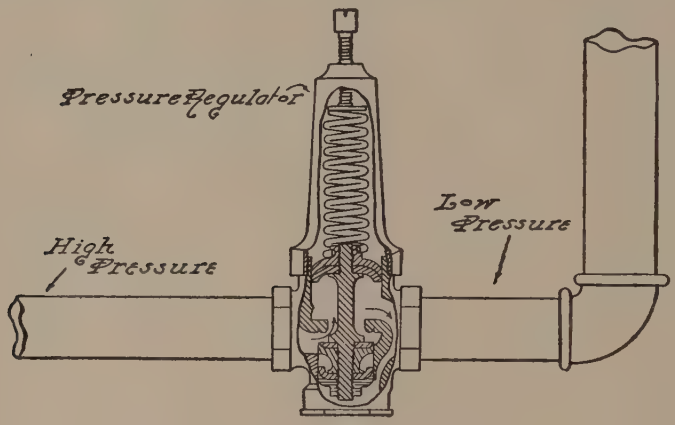


Fig. 263.—Use of Pressure Regulator.

break in the main, the regulator remains closed, thus preventing the siphonage of the boiler. The action of the pressure regulator is automatic, and when once set needs no further attention. The regulator shown in Fig. 263, works by means of a spring which is compressed, the spring being put under any desired tension by screwing down on the set-screw at the top.

A few remarks are necessary concerning the running of water pipes.

They should always be so run that no sags or dipping of the pipe may occur and thus form a trap which cannot be drained. When piping in which sags exist, must be drained in cold weather in the event that the house is to be vacant, it is impossible to drain the traps thus formed, and their contents often freeze and burst

the pipe, whereas the owner has assured himself of protection against this trouble by having the system properly drained.

Pipes should never be run against cold cellar walls, or other walls that may at any time be exposed to frost. When it is necessary to so run them, however, they may be protected by covering them with hair felt or other similar material, or by boxing them. Several concentric boxes with 1-inch air spaces between them provide excellent protection to pipes against extreme cold. It is often

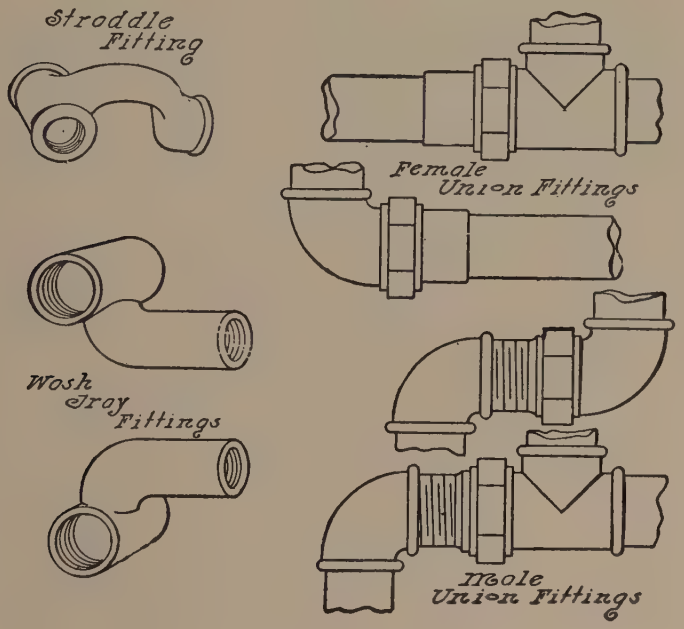


Fig. 264.—Special Supply Fittings.

a good plan to run the main supply pipe through the cellar underground as far as possible, this course not only preventing freezing, but keeping the water cooler than when run overhead.

The "sweating" of exposed water piping is a matter which causes much trouble. It is caused by the formation of condensation on the surface of the pipes, the moisture forming in sufficient quantity to flow along the pipes and drip off. The reason for this trouble is that in warm places the moisture of the air condenses against the sides of the cold pipe. It may be overcome by covering

such pipes. It sometimes occurs between floors, the moisture dripping down onto the ceiling below. In this case, a sheet metal gutter run under the pipe and pitched toward one end, and dripping into a drip pipe effectually remedies the difficulty. Such a drip may be carried into an open cellar fixture. There are several special supply fittings which are of excellent service, a few of which are shown in Fig. 264.

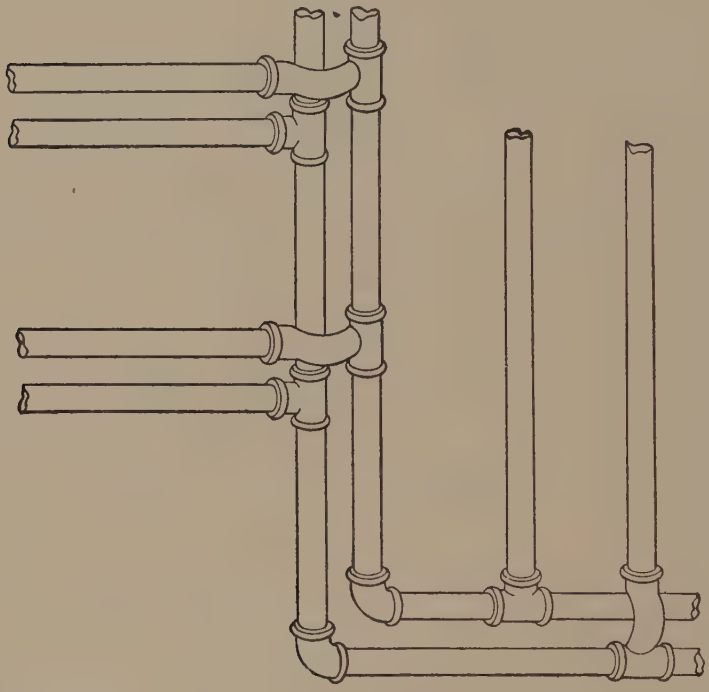


Fig. 265.—Use of Straddle Fittings.

The straddle fitting is a most valuable fitting for use on parallel lines of hot- and cold-water pipe. In many places throughout the house the hot- and cold-water pipes will be found running side by side, and in the use of ordinary fittings it is usually a very awkward undertaking to cross over one of these pipes with a branch from the other. The straddle fitting, as its form shows, is designed for this special purpose. The curved part of the fitting is of sufficient radius to entirely clear the pipe which it must cross.

The use of the straddle fitting is shown in Fig. 265, from which it will be seen that a fitting of this style not only adds greatly to the appearance of the work, but saves labor and the use of a number of fittings.

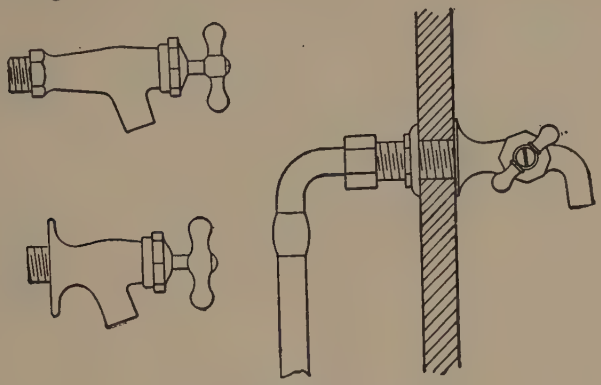


Fig. 266.—Wash-tray Bibbs.

Regarding the running of the hot- and cold-water pipes side by side, when so run horizontally the hot water should ordinarily be run above the cold water, as the heat radiated from the hot water

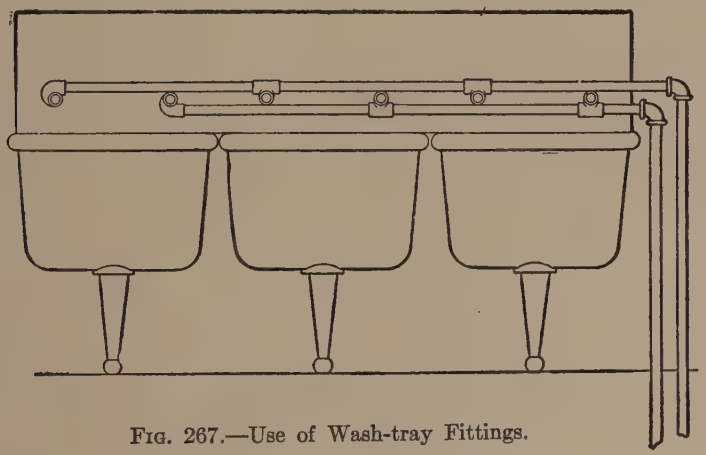


Fig. 267.—Use of Wash-tray Fittings.

will affect the cold water to a greater degree if the latter is run above. The male and female union elbows and tees shown in Fig. 264 represent another valuable type of fitting. It will be clear that fittings of this type are of great value where the work

is close, and there is not sufficient room in which to use a tee or elbow and a union.

In Fig. 266 are shown several different styles of wash-tray bibbs. In the use of the ordinary faucets on wash trays, with the handle upright, there is often difficulty, owing to the projection of the bibb handles so high up as to prevent the use of covers on the trays.

The wash-tray fittings to be seen in Fig. 267 are fittings which allow neat work to be installed in connection with wash trays. By means of them, the wash-tray bibbs may be kept on a straight line, as shown in Fig. 267. In the use of ordinary tees and elbows, the bibbs are on two horizontal lines, the hot-water bibbs being on a line above the cold-water bibbs. The wash-tray elbows and tees are each made in two styles, one to be used on the upper line, throwing the bibb opening down, and the other to be used on the lower line, to throw the bibb opening up.

CHAPTER XXIII

RANGE BOILERS—THEORY OF CIRCULATION

The subject of cold-water supply, which has already been considered, is a comparatively simple matter. On the other hand, the subject of hot-water supply involves numerous difficulties which do not enter into the former branch of work. Indeed, the proper installation of the hot-water supply system is often a most perplexing problem, one demanding a knowledge of the theory which underlies the action of hot water, and the application also of knowledge which comes by experience. In this branch of plumbing construction, more than in any other, practical experience counts for a great deal. It is the employment of a knowledge of the theory of the subject in combination with the practical knowledge that comes by experience, that produces the perfect system of hot-water supply.

Many a system of hot-water supply produces results which, to the person unacquainted with the subject, would seem to be all that is required of it, whereas, if the same system had been properly constructed, it would have been able to do better work, and a greater amount of it. A great deal of the supply work that is installed, is like all other construction work—it will answer the purpose, while at the same time it is not capable of performing its work as it should be performed. As in the case of the drainage and vent systems, the perfect operation of the hot-water supply system depends very largely on the observance of the small points which, to the uninitiated, would often appear to be of small consequence. By the observance of these small points, one workman will install a system which will produce excellent results, while another workman, careless in observing these same points, will construct a like system from which only poor or fair results are to be obtained.

The principle of circulation underlies all hot-water supply

work, as well as all heating systems, whether hot water, steam, or hot air, and a thorough understanding of this principle is necessary to an understanding of either subject. For the purpose of this explanation, it is necessary to understand something of what is known as the molecular theory. According to this theory, all bodies, regardless of their composition, are made up of molecules or particles, these particles being so minute, and of such numbers, that they cannot be estimated. These particles are in constant motion or vibration, the path which each molecule traverses being so small as to be immeasurable. When heat is applied to some bodies, metals, for instance, these particles are set in more violent vibration, and the result, as is well known, is the expansion of the body. If heat continues to be applied of sufficient intensity, the vibrations of the molecules become so rapid and so violent that they refuse to hold together, and separate from the main body, that is, the body melts. Thus it will be seen that by means of the molecular theory, the action of expansion and contraction, the melting of metals and many other phenomena may be explained. Indeed, it is by means of this theory that innumerable actions and operations may be explained.

The molecular theory may be applied much more extensively than the above, but the simple statement as given, will be sufficient for the present purpose. As a means of illustration, suppose that a block of ice be subjected to heat. In its original form, the ice is a solid, compact mass. As the heat is applied, however, according to the above explanation, the particles or molecules of the ice begin to vibrate more rapidly, finally refusing to hold together longer, and the ice melts and forms water. If heat continues to be applied to the water its temperature rises and its molecules expand. The vibration of these molecules finally reaches such a stage that it is stronger than atmospheric pressure, and in their expanded state, being lighter than the air, they rise into the air in the form of steam. Thus, by the application of heat, the original block of ice has been changed to water, which is a fluid, and the water in turn has been changed to steam, which is a vapor. Each of these actions is an example of the action of circulation.

Now, when this same principle is applied to the range boiler, as shown in Fig. 268, the action is the following:

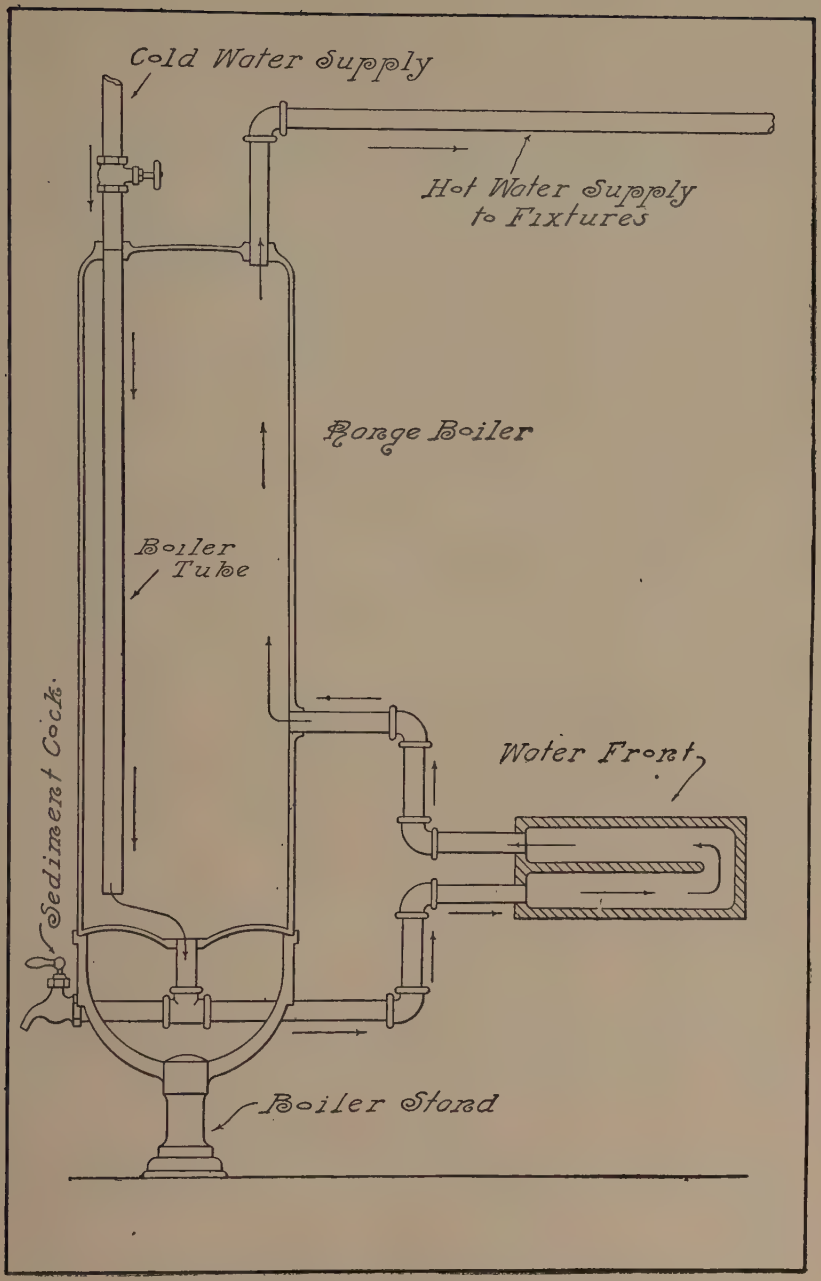


FIG. 268.—Connections for Range Boiler.

Cold water enters the water front of the range, from the boiler, and in passing through the water front is heated. When heated, as already seen, the particles of water become expanded, and therefore lighter than the colder particles, with the result that they rise, as indicated in the illustration by arrow heads.

After entering the boiler, the heated water will continue to rise to the highest possible point, or until it has become cooled.

Because of the tendency of hot water to rise, the hottest water will be found at the top of the boiler. While such is the action of hot water, a reverse action occurs in the case of cold water. The particles of cold water being unexpanded, are much heavier than those of the hot water, and their natural tendency is to fall to the lowest points. Therefore, the coldest water will be found at the bottom of the range boiler. In order, also, that this natural tendency may be favored as far as possible, the supply of cold water to the range boiler is carried through a pipe directly to the bottom of the boiler, instead of being connected to the top.

Inasmuch, also, as the storage of hot water is at the top of the boiler, rather than at the bottom, the pipe supplying fixtures with hot water should always be connected at the top of the boiler. A connection at any other point would give entirely unsatisfactory results.

The construction of a successful hot-water supply system, then, depends upon the running of pipes of proper sizes in such a manner as to provide the easiest and most natural path for the hot water. Having now seen that the hot-water supply depends upon the circulation of hot water, it will be readily understood that the same principle underlies certain other actions. For instance, hot-water heating also depends upon the circulation of hot water; steam-heating upon the circulation of steam; hot-air heating upon the circulation of air, and ventilation upon the circulation of air. The action of the local vent, moreover, depends upon the circulation of hot air.

The hot-water boiler in common use, such as shown in Fig. 268, has four openings, two at the top, one at the bottom, and one on the side. Into the latter, the hot water or flow pipe from the water front is connected. The connection shown in Fig. 268 is made under favorable conditions, the water front being at such

height that a good rise can be obtained between the range and boiler, the range being located in close proximity to the boiler. The latter is a condition always to be desired, but not always to be obtained.

With a short range connection, there is less loss from friction of pipe and fittings, and less loss of heat than would result in the use of a long flow pipe.

In the use of a long flow pipe there is also much greater

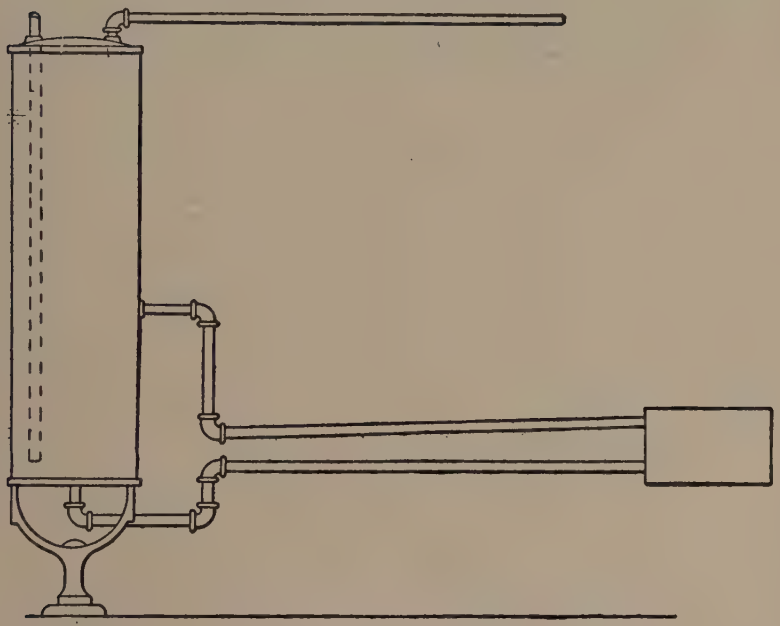


Fig. 269.—Flow Pipe of Range Connection Pitching in Wrong Direction.

danger of a dip or sag in the pipe, and greater danger that it will pitch in the wrong direction. The tendency of hot water being upward, the greatest care should be taken that the flow pipe from the range pitches upward at all points.

The connection shown in Fig. 269 will at once be seen to be a very poor piece of work, from which satisfactory results cannot possibly be expected.

It is a very common error, however, to run the flow with a pitch in the wrong direction. The best practice in the construc-

tion of range connections, calls for the use of 45-degree elbows. Their use is shown in the illustration of Fig. 270. The advantage gained is due to a decrease in the friction of the water in passing through a pipe so provided. The path for the hot water made by the flow pipe of Fig. 270, is clearly much more smooth than it would be if the bends were made abruptly by means of the common 90-degree bends or elbows.

In constructing the range connection, provision should always be made for drawing off the contents of the boiler without the necessity of disconnecting any part of the connection. This is

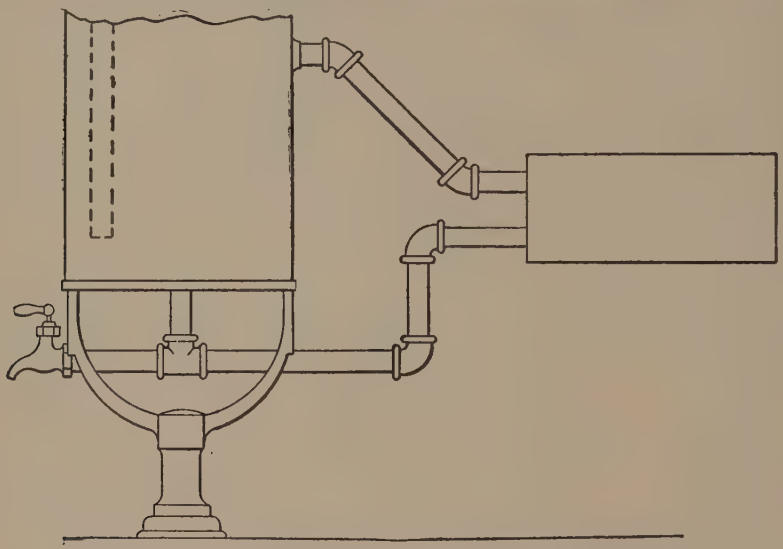


Fig. 270.—Use of 45 Degree Elbows on Range Connections.

accomplished by the use of a sediment cock, as shown in Fig. 268. A common bibb is generally used for this purpose, and it should be located at the lowest point in the range connection, in order that all the water in the boiler and in the range piping may be drawn off. In order to make the water flow out of the boiler, it is necessary to exert atmospheric pressure upon the contents of the boiler, and this is generally done by opening a bibb on a floor above the boiler, or by disconnecting one of the boiler couplings at the top of the boiler. The objection to the use of the sediment cock as the only means of draining the boiler, is that the water must be

disposed of by drawing it off into pails, which is naturally a long and tedious undertaking.

In Fig. 271 is shown a method of draining the boiler into a convenient fixture trap, usually that of the kitchen sink. This method consists in running a wrought-iron or lead waste from the cold-water range pipe, and providing the connection with a stopcock. When the stopcock is opened, the contents of the boiler

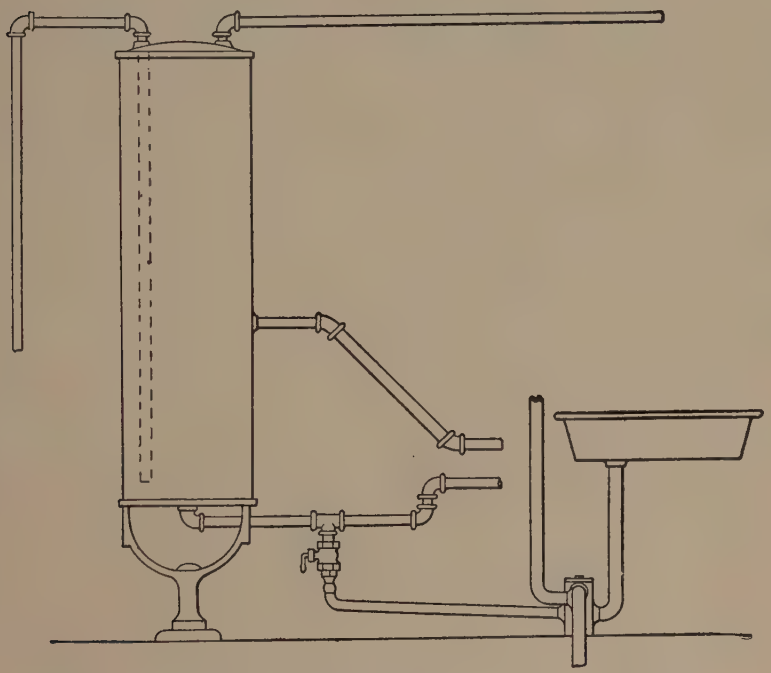


Fig. 271.—Drainage of Boiler into Sink Trap,—Poor Practice.

quickly pass off into the drainage system, through the trap to which the draw-off pipe is connected.

This method, however, is not to be considered good practice, as by means of it, direct connection is made between the water supply and drainage systems. These two systems should not be directly connected in this instance or in any other instance. The connection of the boiler waste into the kitchen sink trap is a very common one on old-style work, but is in general practice but little at the present time. Another somewhat similar method of drain-

ing the range boiler is that of Fig. 272, in which the connection is made into the drainage system, the waste pipe being served by its own trap. This is open to the same objections that apply to the work of Fig. 271.

The proper method of providing drainage for the range boiler is to be seen in Fig. 273. In this case, the boiler waste is con-

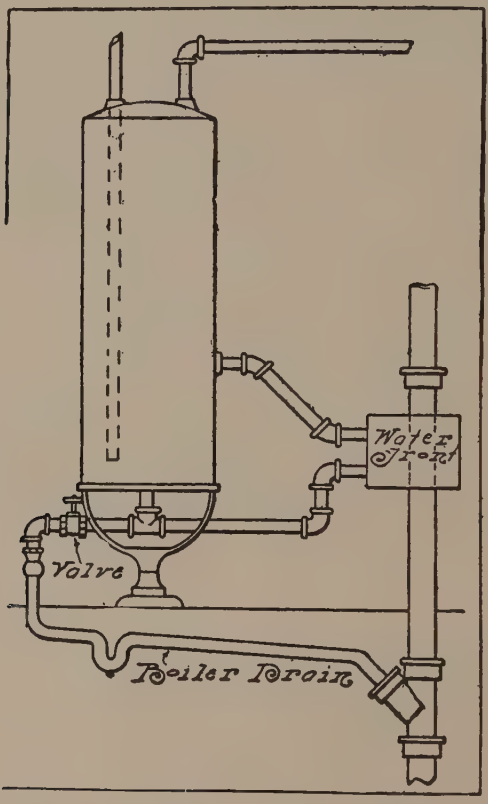


FIG. 272.—Drainage of Boiler into Drainage System—Poor Practice.

ducted into an open fixture, the laundry tubs in the basement. Such a method, while providing fully for the drainage of the boiler, avoids direct connection into the drainage system. There often collects in the bottom of the range boiler a very heavy body of rust and sediment, which also often collects in the range connection, sometimes almost entirely filling it. The water front

becomes filled with sediment very often also. When the latter occurs, the water front must be taken out and cleaned. A very effective method of doing this work is to heat the water front over a hot fire. If possible to heat it over a forge the work can be done most effectively and easily. This dries the sediment, and

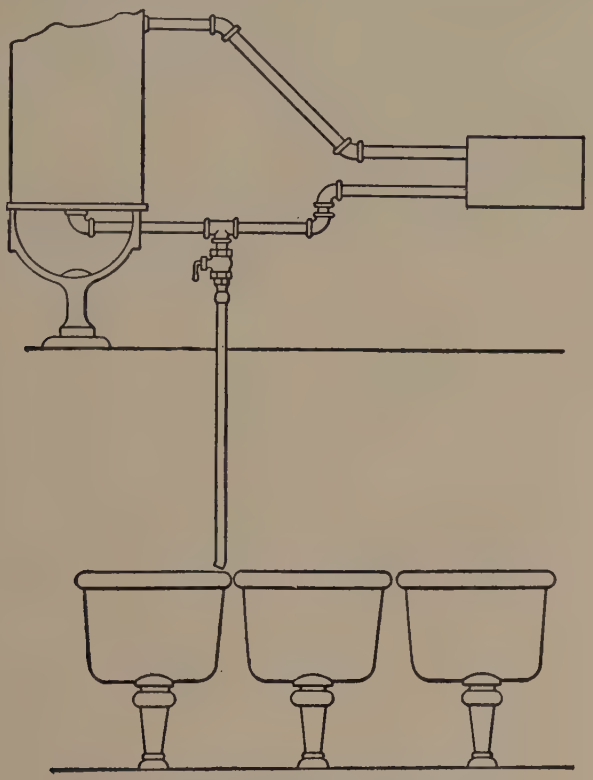


Fig. 273.—Proper Drainage of the Range Boiler.

that which does not crack and flake off can usually be dislodged by means of a rod or by hammering the casting.

Special devices of merit are on the market, by means of which the sediment may be drawn off direct, without drawing off the contents of the boiler. In these devices, the water is taken into the cold-water range pipe from a point above the top of the collection of sediment.

In some sections of the country, very little trouble is experi-

enced from rust and sediment, while in others, much trouble is experienced. Every possible precaution should be taken against the filling up of the boiler connections and water front with sediment, as it results in checking the free circulation of the water. In addition, the presence of rust and sediment produces a discolored water, unfit for kitchen, laundry, or toilet purposes. Another evil, encountered in some sections, is the depositing of lime in the pipes and in the water front. Special devices for the prevention of this trouble are also on the market, and for them, satisfactory results are claimed.

In the proper action of the range boiler many points are to be considered. As already stated, it is very essential that the flow pipe should be properly graded between the range and boiler, never being allowed to dip or sag. Another feature, which is too often overlooked, is the maintenance of a good fire in the range. If the body of coal in the fire box is thin, or full of ashes, it cannot be expected that the water front will properly perform its work. In order that it may do its best work a live fire should be maintained. Very often, the cause of poor heating is due to the use of coal of too large a size. Under such conditions the air spaces between the coals is of such an amount as to have a cooling effect upon the fire, and to prevent good contact of the body of live coals against the water front. The troubles just named produce similar results in heating systems. It very often happens that people enter complaint to the plumber that boiler work which he has installed is not properly constructed, and is not giving good service, whereas the sole cause of such results is the poor management of the range fire. This is true to such an extent, that the workman of experience, when called upon to pass judgment on such work, will generally, after an inspection of the range connections, look at the range fire, as the most probable cause of the trouble.

Another source of poor results in range-boiler work is the wrong proportion of heating surface in the water front as related to the size of the boiler to be heated. The heating surface may be too great for the size of the boiler, or it may be too small. If too small, the water will not heat properly, and if too great, it will overheat, boil and form steam, causing the kicking and hammering so often to be heard in range boilers. Such results are not

only of great annoyance to the inmates of the house, but are injurious to the boiler and piping. Obstructions in the range connection must be avoided. These obstructions might result from collections of rust and scale in the connection, especially if of iron pipe, from lime deposits, from union gaskets that had worked into the pipe, and from other causes. An obstruction, if serious, generally causes the overheating of the water, the consequent formation of steam, with the same results as mentioned above.

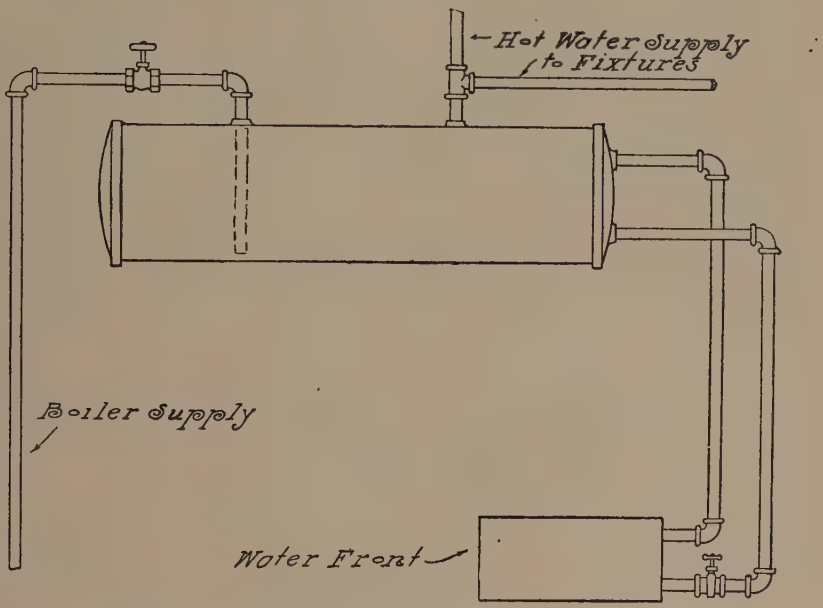


FIG. 274.—Connections for Horizontal Range Boiler.

Range connections of too small pipe should not be used, as under such conditions the evils of overheating the water passing through the water front may arise. If iron pipe is to be used, nothing smaller than $\frac{3}{4}$-inch pipe should be considered for the range connection, as smaller sizes will more readily fill up. If brass or lead connections are used, it is safe under some conditions to use $\frac{5}{8}$- or even $\frac{1}{2}$-inch pipe. Even in their use, however, it is far better practice to make the range connection of nothing smaller than $\frac{3}{4}$-inch pipe.

Thus far, mention has been made only of the vertical boiler.

The horizontal range boiler is also much used, though not to the extent on small work that the vertical boiler is. The principles governing the installation and operation of horizontal boilers are in no way different from the principles already given relating to vertical range boiler work.

In Fig. 274 is shown a common method of making horizontal range boiler connections. The cold-water supply to the boiler is conducted through a boiler tube to the bottom of the boiler, as in

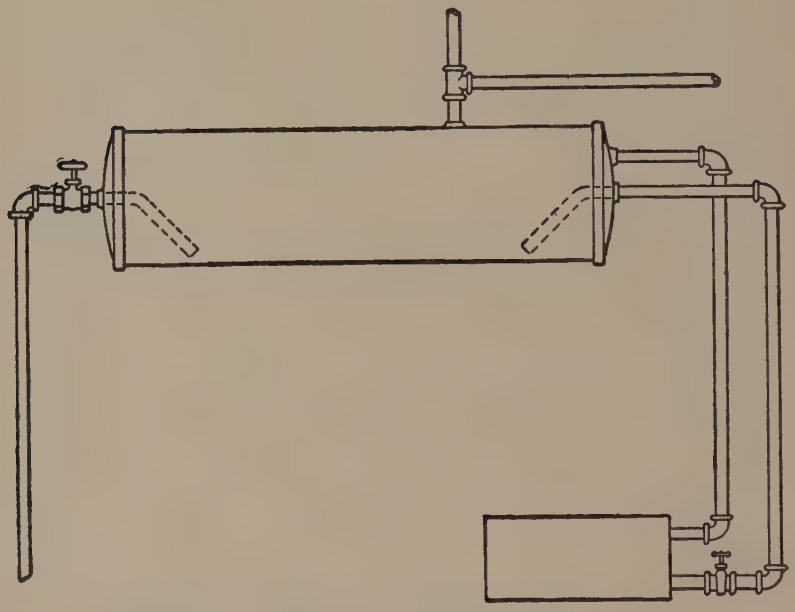


Fig. 275.—Connections for Horizontal Range Boiler.

the use of the vertical boiler. In this illustration, the flow pipe from the range is connected into the upper part of the end of the boiler, and the cold water out of the bottom. The hot-water connection to the fixtures is generally made as shown, at the same end of the boiler that the flow pipe from the range enters, as the water at this point is fully as hot as at any other point in the boiler.

In Fig. 275 another method of connecting the horizontal boiler is to be seen. In this case, the boiler supply is connected at the center of the end and carried to the bottom of the boiler by means

of a bent boiler tube. The cold-water connection from the boiler to the range is made through the center opening of the opposite end, the water being taken from the bottom through a bent pipe, as shown. The flow pipe from the range and the flow pipe to the fixtures are connected as shown in the preceding illustration. The boiler supply should always be provided with a valve, located at an accessible point near the boiler.

In connection with the use of the supply valve, when used on the pressure boiler, the precaution should be taken of opening a

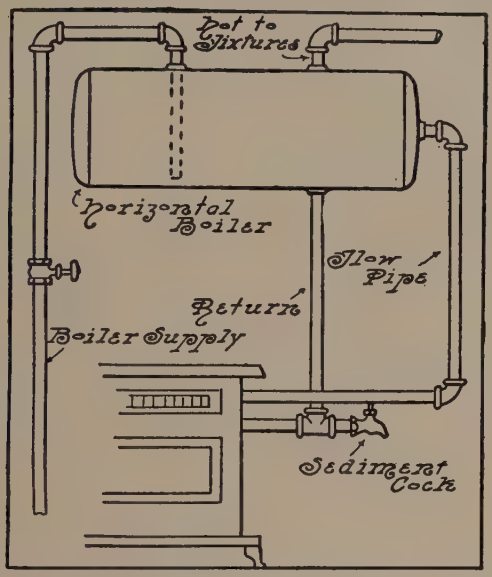


Fig. 276.—Connections for Horizontal Range Boiler.

hot-water faucet if the range fire is in action. The reason for this is that when the valve is closed, all opportunity for the expansion of the hot water is cut off, and the opening of a hot-water faucet is necessary to provide a vent for the expansion. It will be seen that with a heavy fire continuing to deliver hot water to a boiler on which there is no expansion, serious trouble is bound to occur if such conditions are allowed to exist for any length of time. A third method of connecting the horizontal range boiler, differing only in minor essentials from the two methods already mentioned, is illustrated in Fig. 276.

Fig. 277 illustrates a method of connecting the horizontal boiler which is often made use of, but which is open to objection. In the first place, it will be noted that the boiler supply is taken into the bottom of the boiler, at a point directly beneath the outlet of hot water to the fixtures. This means that a stream of cold water will be thrown directly up into the body of hot water, and into the entrance of the flow pipe from the boiler, which would naturally be detrimental to securing the best results from the boiler. Not only should the boiler supply be conducted to the bottom of the boiler, as indicated in the two preceding illustrations,

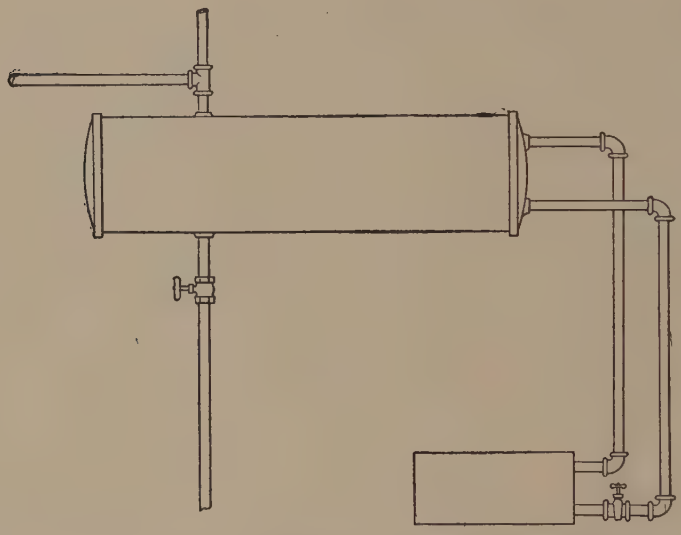


Fig. 277.—Wrong Connections for Horizontal Range Boiler.

but the hot-water supply pipe to fixtures should be taken out of the end of the boiler which is entered by the flow pipe from the range.

Fig. 278 represents another common method of connecting horizontal range boilers, which is open to objections similar to those named in connection with Fig. 277, though the errors are not so serious. As to the use of materials for range connections, lead, brass, and galvanized wrought iron are commonly employed. Probably galvanized wrought iron is most commonly in use. The selection of proper material for this work depends largely on the chemical properties of the water supply, as also, the selection of

piping for the entire house supply system. Some waters act very rapidly on wrought-iron pipe, the action being so severe in many cases, that the range connections must be renewed at comparatively frequent intervals, if of this material. Under such conditions, the use of brass or lead is necessary.

Brass connections are perhaps the most satisfactory. Lead connections are more liable to sag and form traps, which, as already seen, results in unsatisfactory work. When lead is used

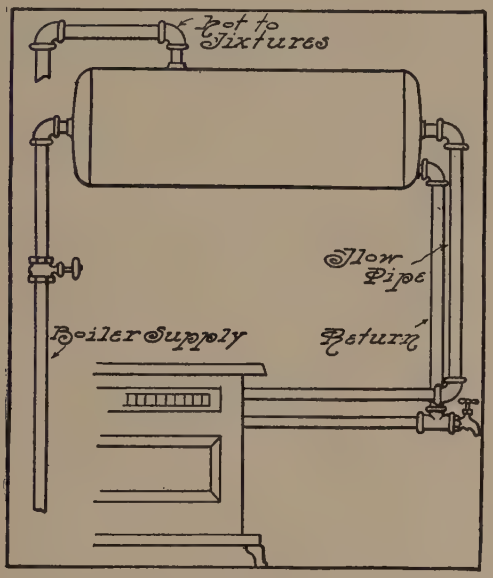


Fig. 278.—The Horizontal Range Boiler Improperly Connected.

on the range connections, it is necessary to use brass boiler connections and water-front couplings. A range and boiler thus connected are shown in Fig. 279. The brass connections make tight by means of ground joints, whereas, in the use of wrought iron, unions with gaskets, or right and left couplings must be used. In the use of lead pipe, wiped joints must be used to connect the pipe with the brass connections. Brass boiler couplings and water-front couplings are also often used in connection with work constructed of wrought iron or brass.

Several forms of boiler couplings are shown in Fig. 280. As

seen from this illustration, they may be obtained in either the straight or bent pattern, for either lead or screwed pipe. Those designed for lead have plain ends, in order to allow solder joints to be wiped to them.

In Fig. 281 are seen several fittings for range boiler work, made either of brass or malleable iron. Water-back couplings are made in several styles, as seen in Fig. 282, for both lead and

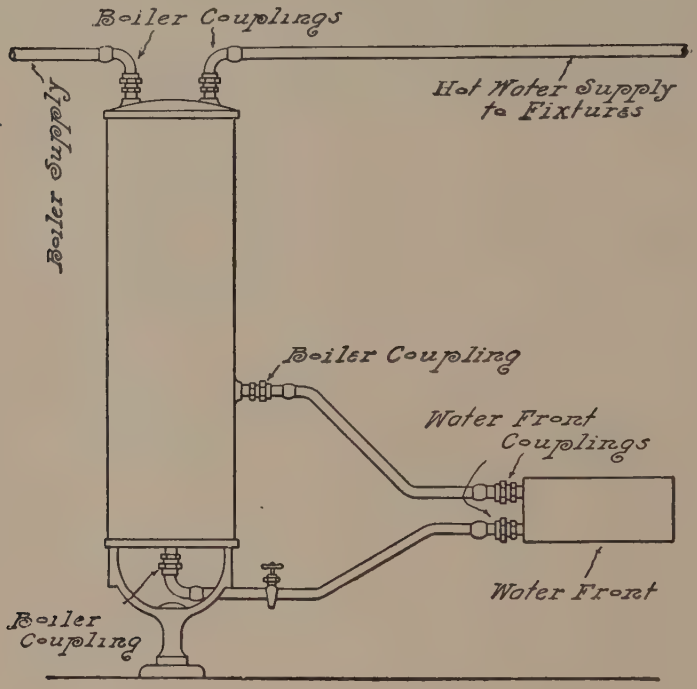


Fig. 279.—Lead Pipe Range and Boiler Connections.

screwed pipes. These also are made straight or bent, with short or long spuds. They may also be obtained with an inside thread on one end. In range boiler work, it will often be found that the flow pipe gives out more quickly than the cold-water connection. The reason for this is that there is much more expansion and contraction on the flow pipe, due to the fact that it carries hot water. The continual expanding and contracting of this pipe, as it alternately heats and cools, will in time weaken the pipe and its joints,

and cause leakage. Even if the heat of the pipe is comparatively even, and the alternate expansion and contraction not great, it is a well-known fact that a heated pipe will not give as long service as a cold pipe.

In Fig. 283 is shown a special device for use in taking

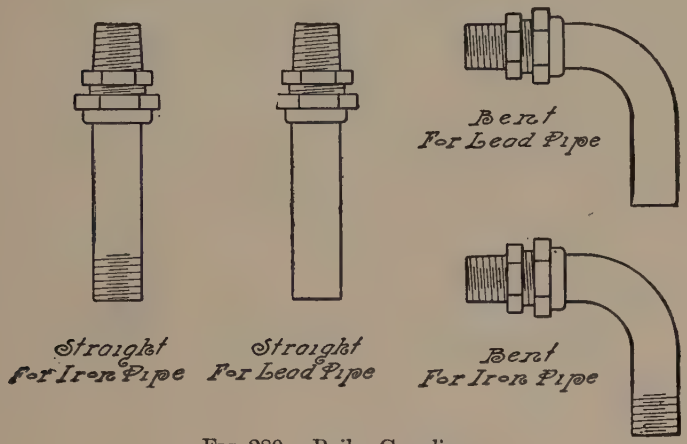


FIG. 280.—Boiler Couplings.

range-connection measurements, known as the center-meter. The device consists of a number of small steel rods and several specially constructed joints. These joints are of aluminum, in the form of small cubes. Through each joint, two holes, slightly larger than the diameter of the steel rods, are drilled at right angles to each other. These two holes are so drilled that they

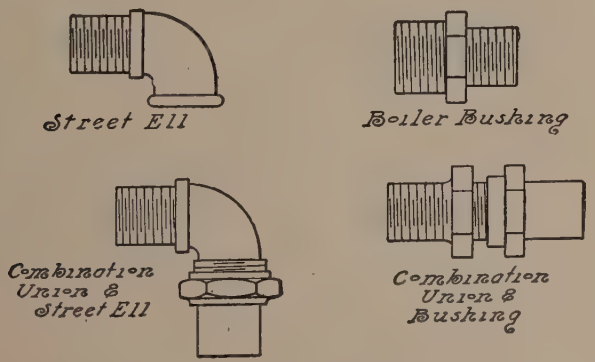


FIG. 281.—Malleable Iron Boiler Fittings.

break into each other slightly, at the point where they cross. By so constructing them, a single set-screw tightens both rods. Four of the rods shown in the illustration referred to, are provided with 1-inch pipe plugs. The center-meter is used in the following way: In measuring for the flow pipe, for instance, the two rods having plugs are screwed into the boiler opening and into the

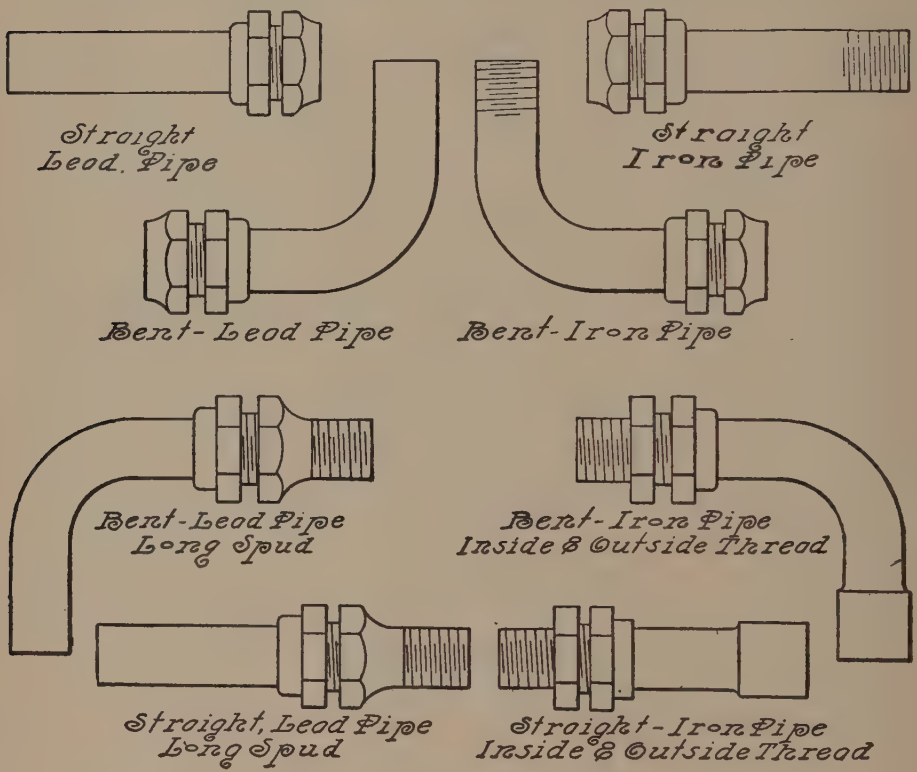


Fig. 282.—Water Back Couplings.

water-front opening. By means of the joints, the rods are then placed in the same position that the flow pipe will take. Measurements can now be taken from center to center, and from end to center, or, if desired, the device may be laid flat upon the floor, and the same measurements taken. The joints are also made with a third hole drilled at 45 degrees, thus enabling the workman to take 45-degree measurements. It is, of course, impracticable to

provide steel rods long enough to use on long-range connections, and if provided, the plumber would find them awkward to carry. In the case of long connections, the rods may be built out as far as possible from the range and from the boiler, and the measurement for the long run of pipe taken in the usual manner between the two last measuring points. The use of this device will be found to save much annoyance to both workman and customer. In the event of wrong or incomplete measurements, it often becomes necessary for the plumber to return to the shop to get out

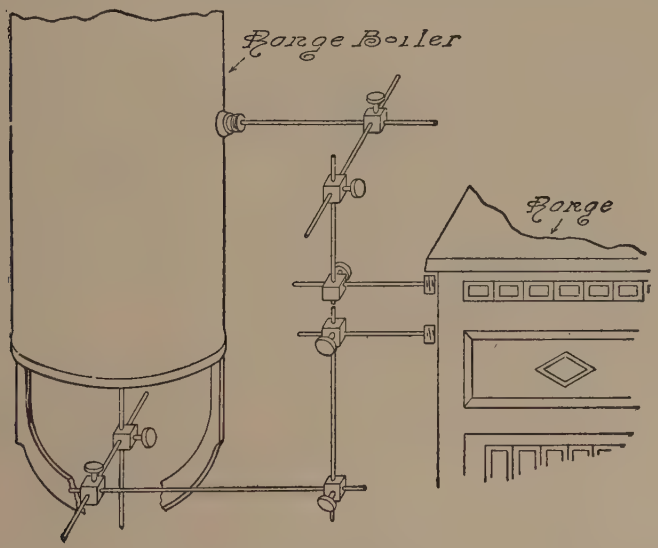


FIG 283.—Use of Center-Meter, a Device for Taking Range Connection Measurements.

additional pipe, which is usually much disliked by the customer. The center-meter, if used properly, cannot make these mistakes, even in the hands of an unskilled person.

In the running of hot-water pipes, there is often opportunity for the exercise of judgment. For instance, in Fig. 284 are shown two methods of running such pipes, one of them a correct method and the other incorrect. The tendency of hot water is always to rise. Therefore, the practice of carrying the pipe from the top of the boiler directly down to fixtures on the same floor as the boiler, and to fixtures below, does not afford a natural path

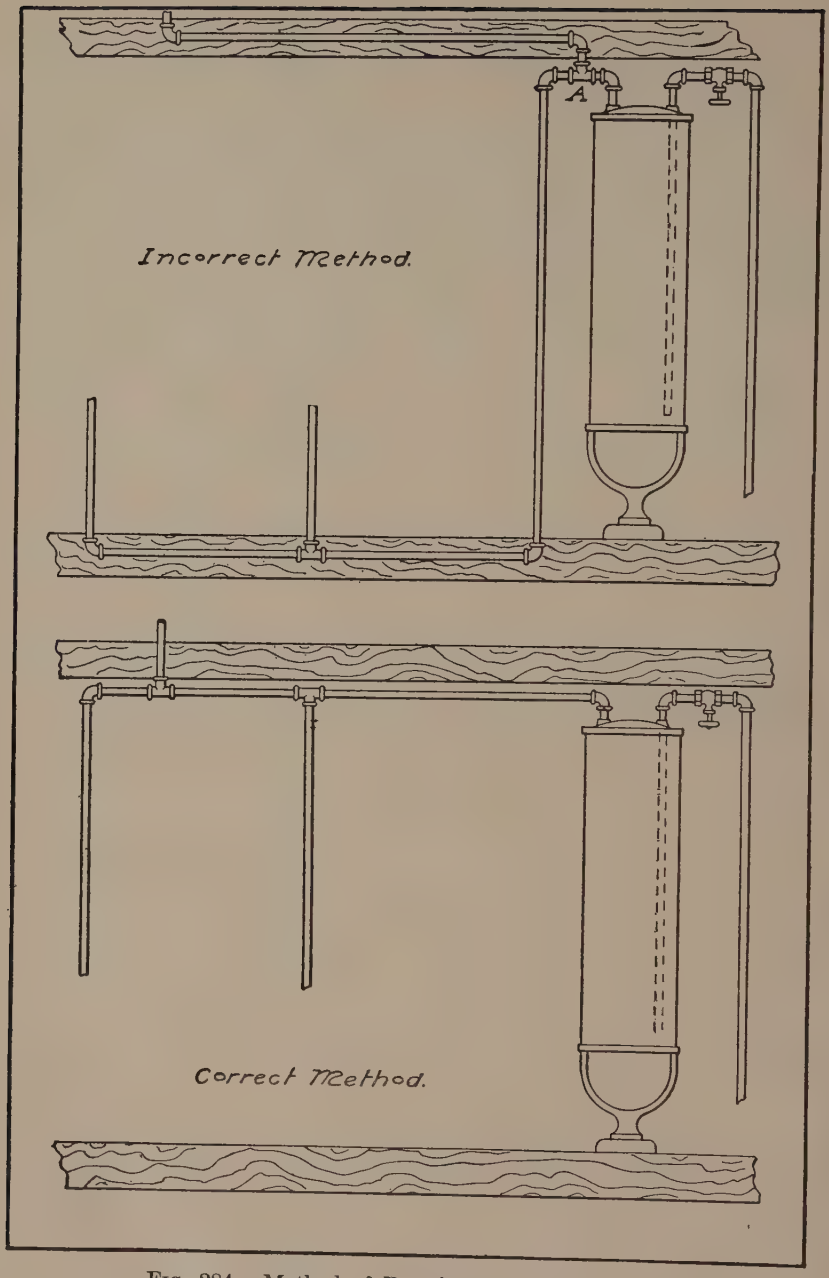


Fig. 284.—Method of Running Hot-Water Pipes.

for the hot water. It means that the hot water must take a downward and unnatural direction, rather than an upward, natural direction. This practice of running hot-water pipes is, nevertheless, a common one. In the instance of Fig. 284, where a connection is taken from the high point, to supply fixtures above the boiler, any accumulation of air will rise in this connection, and escape through the highest hot-water faucet, whenever it is opened. If it were not for this connection, however, there would be danger of the accumulation of air at the high point, which would interfere with the circulation, and very often cause the circulation to cease entirely.

The collection of air in high points in the hot-water pipes, is an evil which must always be avoided, as it is the means of endless trouble in both supply and heating systems. The correct method, shown in Fig. 284, consists in carrying the flow pipe from the boiler horizontally above the boiler, and dropping down with branches to the several fixtures. This method provides the more natural path for the hot water, and is in all ways the more satisfactory method of the two. Ordinarily the hot- and cold-water pipes are run parallel and close together. When so run, the hot-water pipe should be carried above the cold water. The reason for this is that as heat rises, the heat from the hot-water pipe will have less effect upon the cold-water pipe, if run above it.

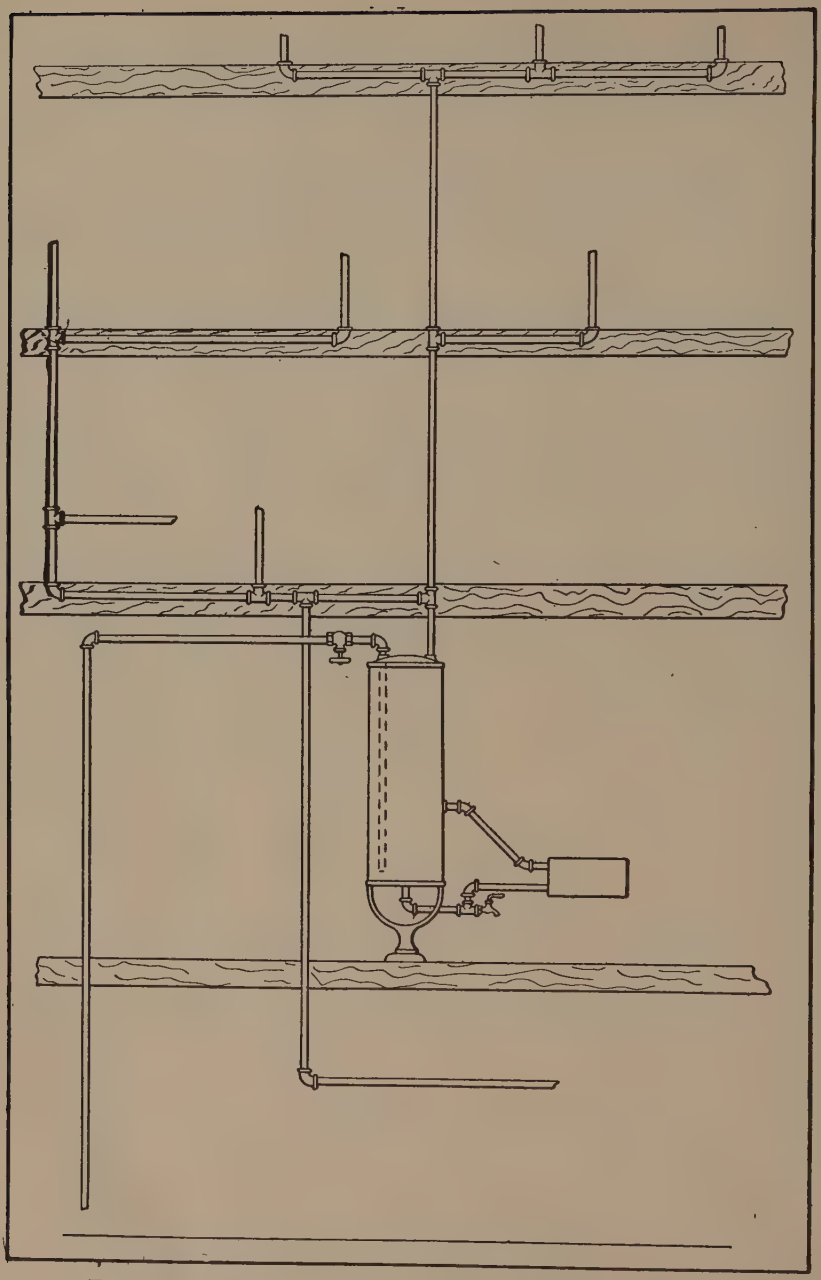


Fig 285.—System of Hot Water Supply without Circulation.

CHAPTER XXIV

CIRCULATING PIPES

In the running of hot-water piping on ordinary work the supply lines to fixtures are run as directly as possible to them, the different branches ending at the fixtures. This method is shown

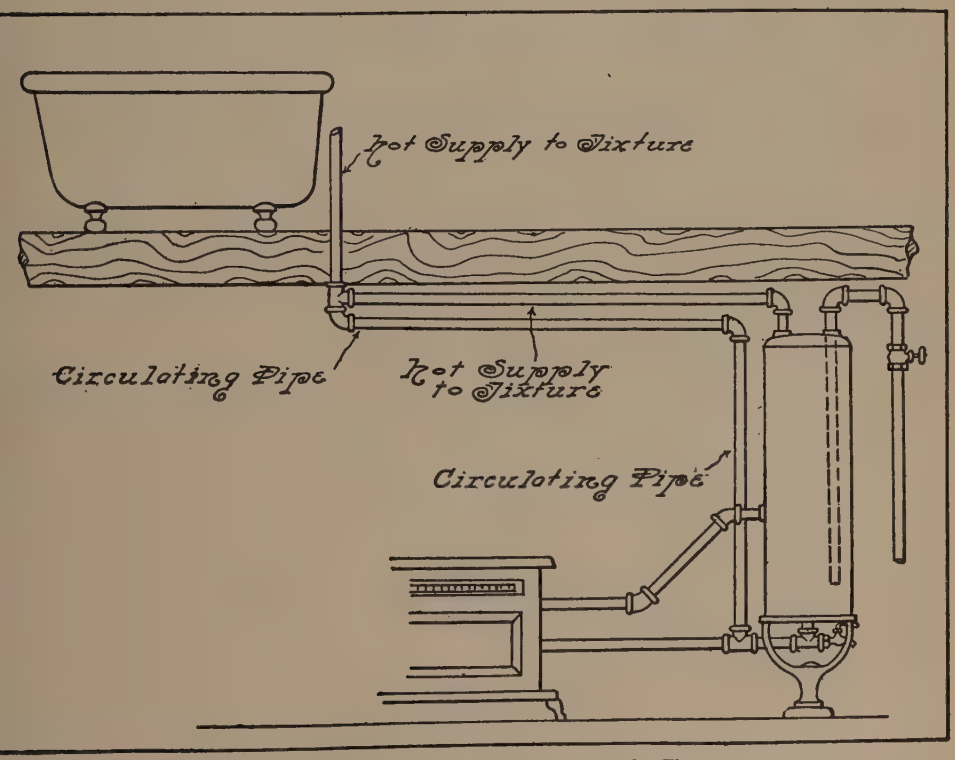


Fig. 286.—Circulation Applied to a Single Fixture.

in Fig. 285. There is great objection to this course many times, and for the following reason. Although the water in the piping is supposed to be hot, it cools very fast under certain conditions, and especially in branches at a distance from the boiler. In many

of these branches, particularly those which supply fixtures not in constant use, the hot-water pipe for a considerable distance from the fixture is generally filled with water that is either cold or nearly so. This means that before hot water can be drawn at the fixture, a considerable length of pipe filled with cold water must be drawn off before the water comes hot. Under all circumstances, this is an annoyance to the person using the fixture, and in many cases, where the supply of water is limited, this unnecessary waste of water cannot be afforded. When the public supply is metered, and must be paid for by the foot, such waste means unnecessarily high water bills.

A remedy for these troubles can generally be applied to nearly all the fixtures of the house, and while the remedy means the outlay of a certain additional amount of money, under most conditions such outlay is an economy in the end. The remedy is the circulation pipe.

Fig. 286 shows the circulation pipe applied to a single fixture, and in Fig. 287 is shown a hot-water boiler providing hot water for the kitchen sink and the bath room, the system being supplied with a circulation pipe. This pipe is nothing more than a return, connected to the flow pipe, and with the latter, forming a complete circuit from the water front back to the water front. The water in the circulation pipe being cooler than that in the flow pipe, falls back into the cold-water range pipe, to enter the water front and be again heated. Thus, the upward tendency of the hot water in the flow pipe from the boiler, and the downward tendency of the cold water in the circulation pipe, produces a continuous circulation of hot water through any line of pipe to which the circulation pipe is connected.

When the hot-water supply line is provided in this manner with a circulation pipe, as in Fig. 286, only a very small amount of cold water in the branch to the fixture must be drawn off before the water will run hot. Branches may be taken off the flow pipe at any point, and run up to fixtures above or carried down to fixtures below. As the work is constructed in Fig. 287, the kitchen sink does not have full advantage of the circulation pipe, as its branch must drop down for a considerable distance to supply it.

The circulation pipe in this illustration might have been run

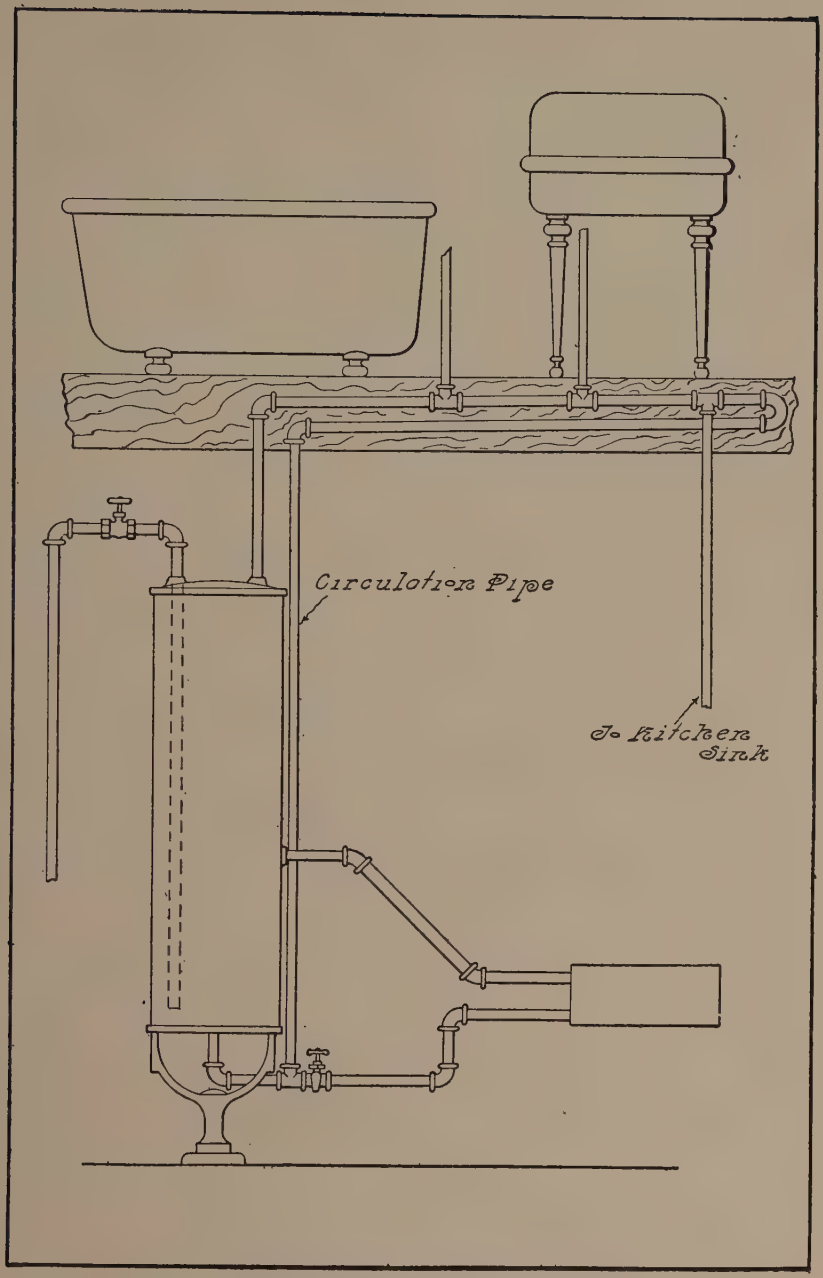


Fig. 287.—Use of Circulation Pipe.

in another way to provide more fully for the kitchen sink. Instead of running the circulation back to the boiler, parallel with the flow pipe, it might have been dropped down to the sink, after passing the lavatory, and a branch to the sink taken out of the circulation pipe, the latter then being carried back and entered into the cold-water range pipe, as shown in Fig. 288.

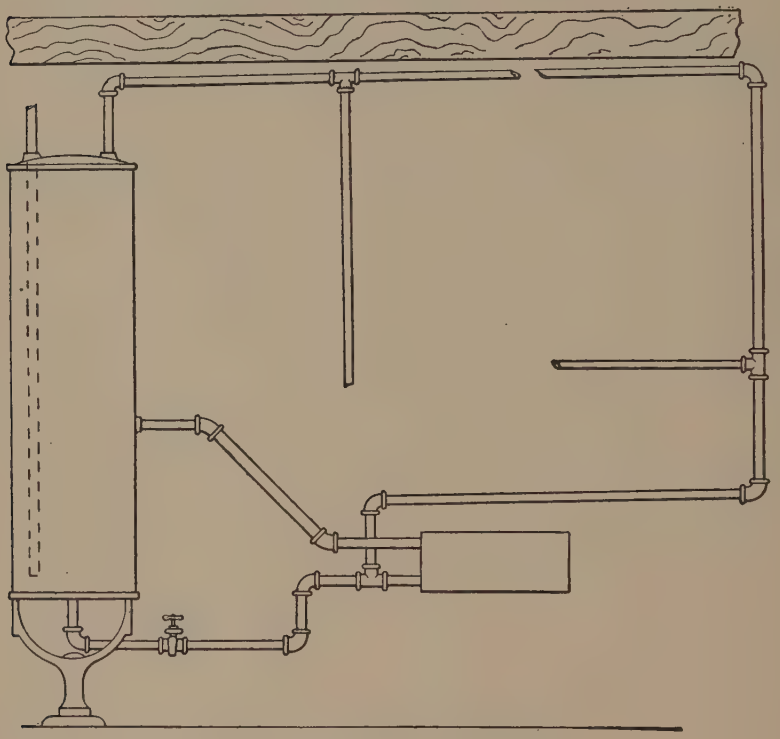


Fig. 288.—Use of Circulating Pipe.

In Fig. 289 is shown the same system of hot-water supply as that shown in Fig. 285, with the addition of circulation. As seen from the illustration, the hot-water supply to fixtures is carried directly to the top floor, where it turns and runs horizontally to the farthest fixture. From this point, the circulation pipe A is carried down and connected to the return of the range connection. If necessary, branches may be taken to fixtures from this circulation pipe, although it is not to be expected that water may be at

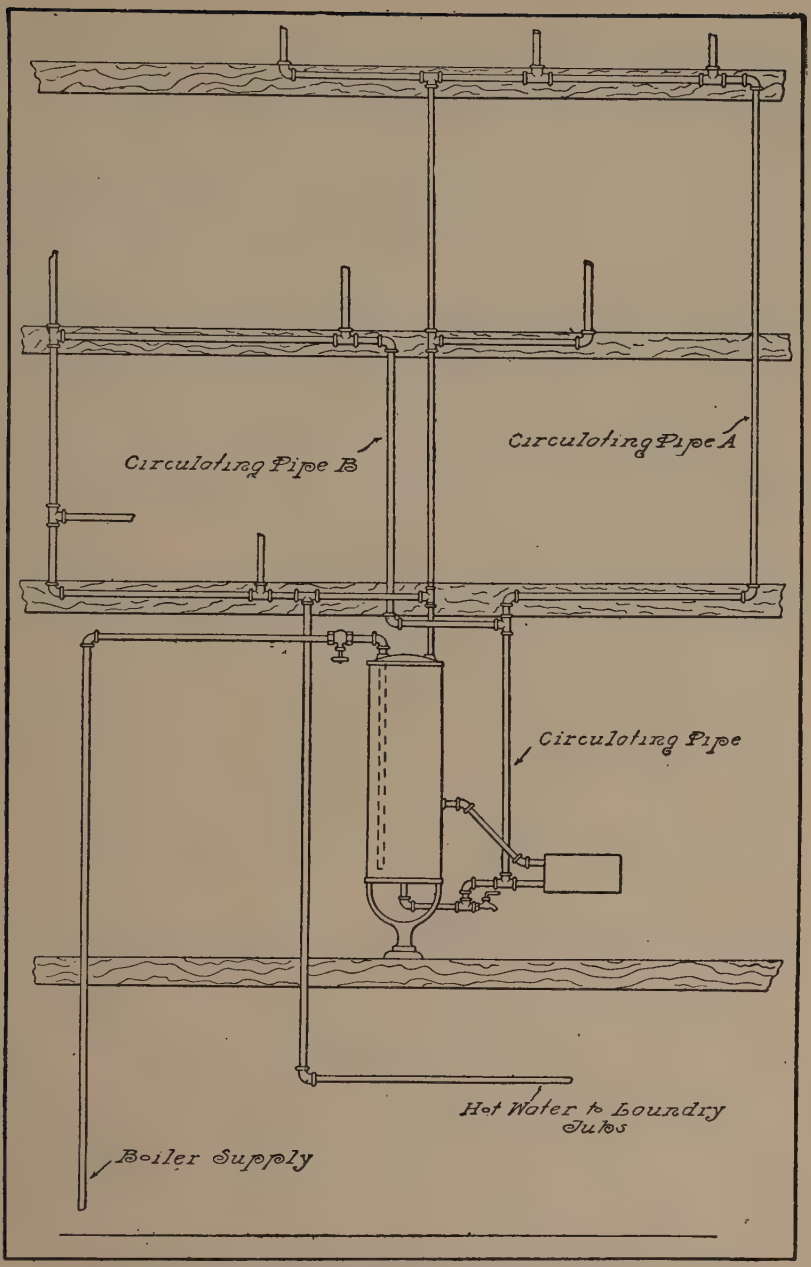


FIG. 289.—Hot-water Supply with Circulation.

once drawn as hot as branches taken off the flow pipe will deliver. Above the boiler a branch connection is taken out of the main flow pipe to serve fixtures in other parts of the house on the two floors above the boiler. After passing the last fixture on the third floor, the circulation pipe B is connected and carried down, being entered into the return or circulation pipe from the first line.

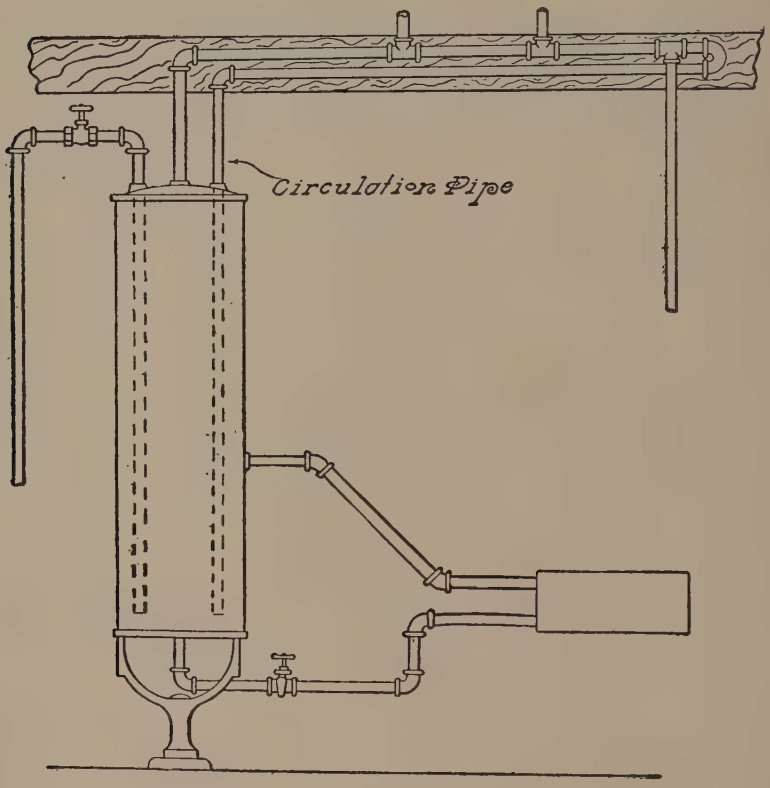


Fig. 290.—The Three-tube Boiler.

For fixtures below the boiler a branch is taken out of one of the flow lines and carried down to the desired points. Circulation cannot be provided for these fixtures because of their position as related to that of the boiler. Therefore, in obtaining hot water at the laundry tubs, it will generally be necessary to draw off the cold water standing in the greater part of the length of pipe running to this fixture. In connection with the work thus far illustrated,

the return or circulation pipe has in each case been carried back into the return of the range connection. This is ordinarily the method followed. In the use of the three-tube boiler another and neater method may be employed. This method is shown in Fig. 290. In the three-tube boiler a second boiler tube may be used, which should run down to a point near the bottom of the boiler,

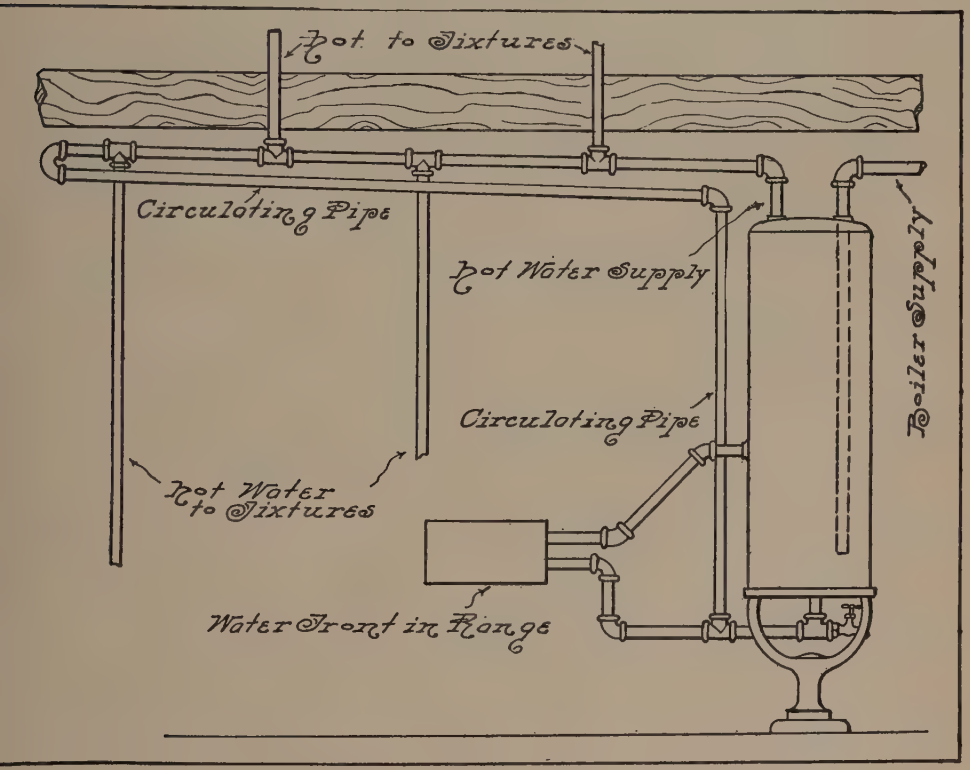


FIG. 291.—Circulation Applied to Fixtures of Small House.

as in the case of the boiler tube used on the boiler supply. To this second tube, the circulating pipe may be connected as shown, which results in returning the cooled water as well as by means of the connection into the return of the range connection. This illustration will also serve to show the manner in which circulation may be provided for fixtures on the same floor as the boiler. This is accomplished, generally, by running the flow pipe

from the boiler horizontally, on the ceiling, above the points where the fixtures to be supplied are located, and dropping from this main flow pipe with branches to the several fixtures. From a point just beyond the branch to the farthest fixture a circulation pipe is carried back to the boiler and connected to the return of the range connection. This is the best that can be done toward securing circulation for fixtures thus located. Necessarily, the cold water must be drawn out of the branch from the main to the fixture before the water will come hot, but even so, the use of circulation under these circumstances will be found to be of benefit. Another method of providing circulation for fixtures on the same floor as the range boiler will be seen in Fig. 288. In this method, instead of running the circulation pipe back to the boiler, just below and parallel to the flow pipe, it is dropped down from the ceiling to a point considerably below, and then carried horizontally back to the range return.

In this method, branches to fixtures may be dropped down from the flow pipe on the ceiling, or taken out of the circulation pipe. While the use of circulation in connection with large hot-water supply systems is a matter of considerable additional expense, in applying it to many small systems, such as commonly found in small residences, cottage houses, etc., where the plumbing is usually centralized, it often means the use of only a very small amount of additional piping. This fact may be seen by reference to Fig. 291, in which circulation is applied to the fixtures of the entire house, by the running of a comparatively small length of pipe. In the foregoing illustrations, circulation has been shown in connection with direct pressure systems only. In Fig. 292 is shown a tank-pressure circulating system of hot-water supply for a residence. There is no material difference in the work, except the use of an expansion pipe on the tank-pressure system. Fig. 292 shows the range boiler heated by means of both kitchen range and gas range, a very common combination.

In Fig. 293 is illustrated a tank system of hot-water supply, without the use of circulating pipes. A comparison of the two illustrations should prove conclusively to the student the practical advantages of circulation and the great saving in water bills following its use.

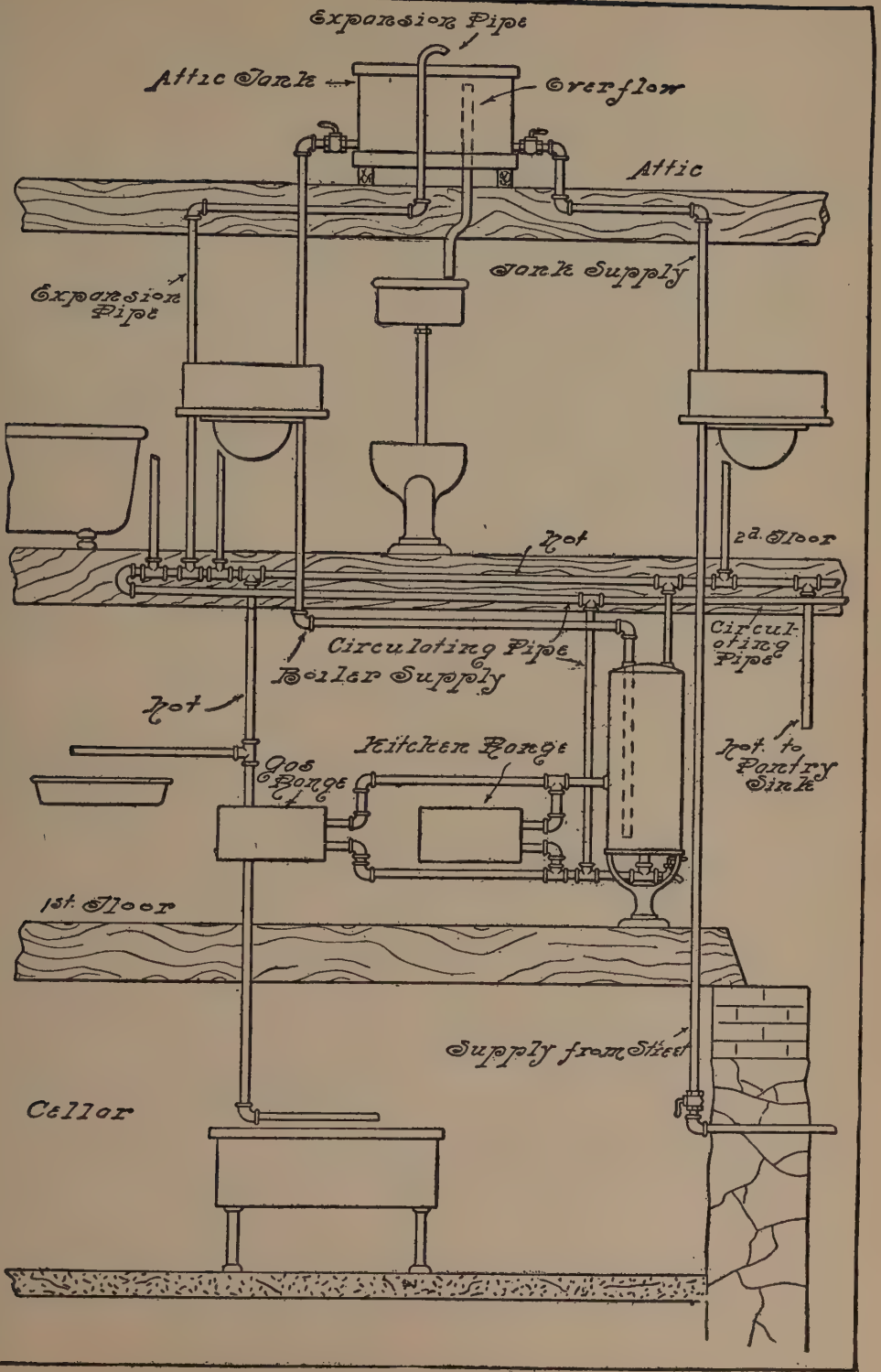


Fig. 292.—Hot-water Supply for Residence, with Circulation.

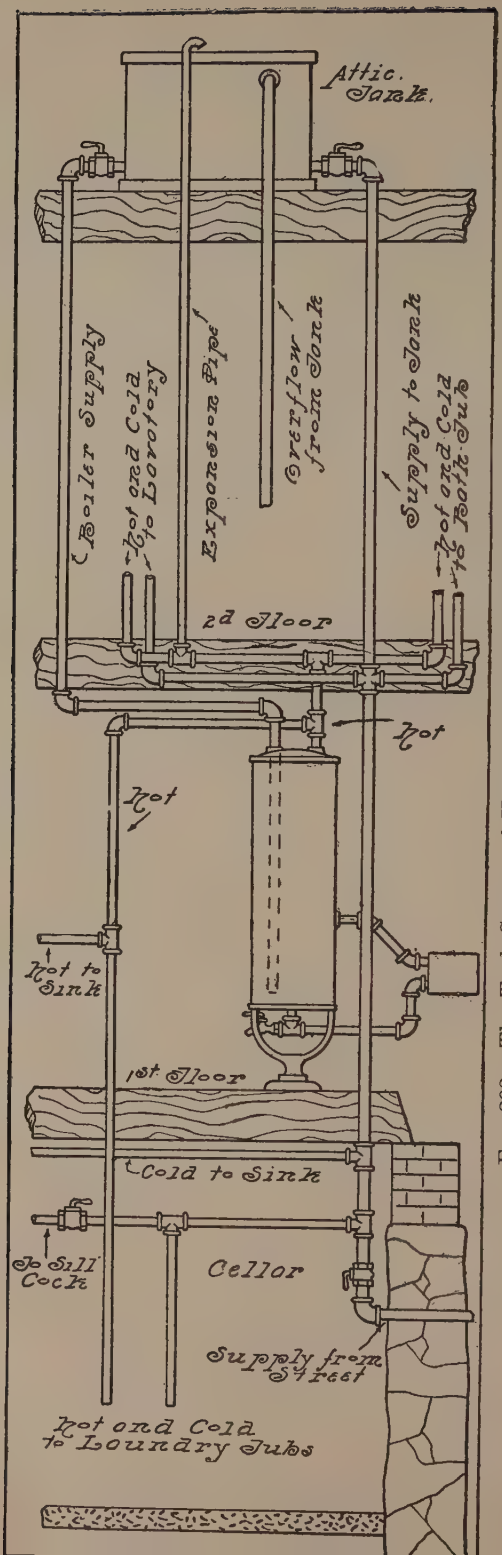


FIG. 293.—The Tank System of Hot Water Supply without Circulation.

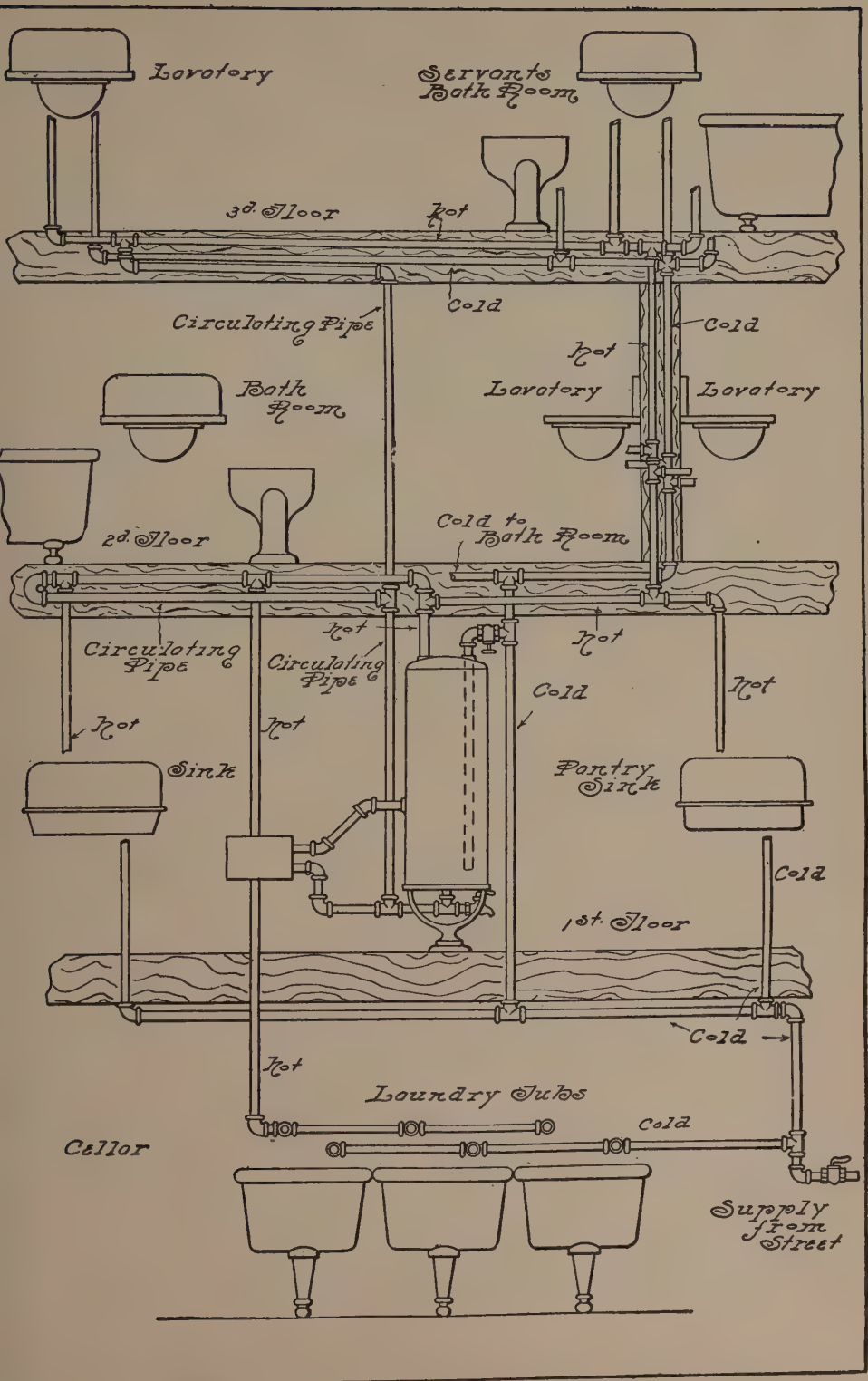


FIG. 294.—Pressure Hot and Cold Water Supply for Residence, with Circulation.

In Fig. 294 is illustrated a complete pressure hot- and cold-water supply system for a residence, with circulation, there being three separate lines of the latter. By many workmen the subject of circulation is not well understood, but a clear understanding of the subject is necessary, if satisfactory supply work is to be constructed. The subject of circulation must be considered at every point on the hot-water supply system, and as conditions are of such great variety, it will be readily understood that to be successful, the workman should be familiar enough with the subject to apply its principles under any and all conditions.

As previously stated, not only is this knowledge necessary, but practical experience in the installation of such work is of very great value. From the preceding consideration of the subject, it should now be clear that the use of the circulating system of hot-water supply is of very great advantage, and this is especially true of large work. It will be found that on large work, and on smaller systems as well, the saving in water bills will not be long in covering the additional first cost of installing circulation, and it goes without saying that such a system is far more convenient than the ordinary system of hot-water supply.

CHAPTER XXV

PROBLEMS IN RANGE BOILER WORK

While the great majority of range-boiler connections are simple and straightforward, there are numerous instances, constantly arising in the experience of the plumber, which call for much ingenuity on his part, as well as a practical and theoretical knowledge of the subject of circulation.

These complex conditions in range boiler work, arise from the varied locations of range and boiler, relative to each other; from the unique requirements that the supply system must fulfill; from the use of more than one boiler; from the use of more than one source of heat; from the requirement that heat by radiation must be obtained from the hot-water supply system, and from numerous other causes. The successful solution of these complex connections that are continually being met by the plumber, present a field of work in which he can display his ignorance of anything out of the ordinary line of work, or in which, if able, he may display a knowledge of the principles of circulation which will gain for him the respect and confidence of his customers. In this chapter some of the problems in range connections, which are continually requiring solution, will be taken up. It should be stated, however, that the problems considered are really few in number as compared to the great variety of such problems which might be considered if space could be devoted to the subject.

Those which are considered, however, are of importance, and a thorough understanding of them will go far in helping to solve other problems in circulation. One of the more simple, but yet important connections, is that shown in Fig. 295, the use of which is to produce a quick supply of hot water. By means of the ordinary connection of the flow pipe, which enters the side of the boiler, hot water is stored in the boiler and from there delivered to the fixtures. When the fire is first built in the range, however,

considerable time must elapse before the hot water delivered to the boiler can store itself in sufficient quantity to be of any service. Before hot water can be delivered to the fixtures from the boiler, the hot water entering the latter must heat up a large body of cold water standing in it. By means of the connection shown in Fig. 295, however, hot water can be delivered directly into the flow pipe from the boiler in a very short time after the range fire has been

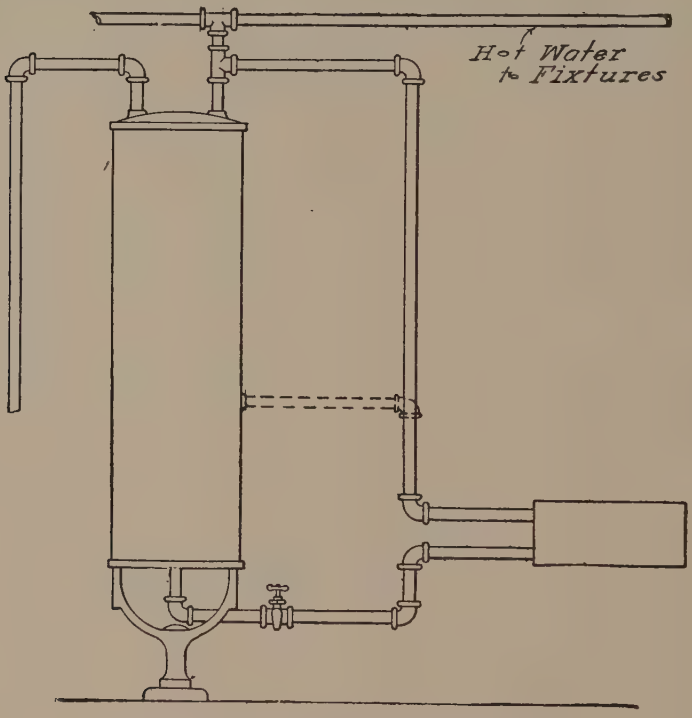


FIG. 295.—Quick-Heating Range Connection.

started. Not only is this advantage gained, but hot water will store itself in the boiler almost as readily when this connection is in use as when the side connection is made. As the water in the flow pipe cools slightly, it must inevitably fall back into the boiler to make room for the hotter water that is being constantly delivered to the flow pipe. It is in this way that storage of hot water goes on.

Under many conditions this form of connection is of special advantage. For instance, in many homes, the kitchen range fire is allowed to go out each night, and when it is rekindled the following morning, hot water will be required as quickly as possible to provide it at the kichen sink. It can be readily seen that in this case the quick heating connection will give far more satisfactory service than the side connection into the boiler.

Fig. 296 will show that this same connection can be provided

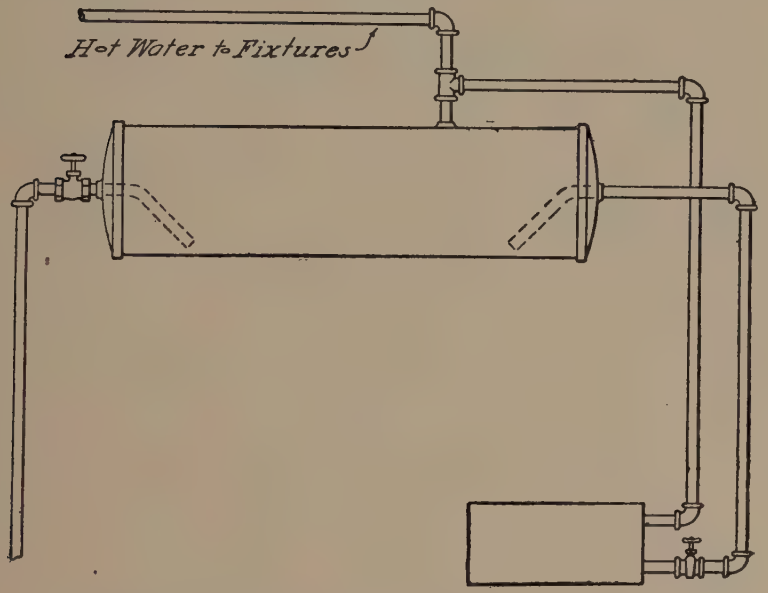


Fig. 296.—Quick-Heating Range Connection for Horizontal Boiler.

for the horizontal boiler equally as well as for the vertical boiler. A modification of the quick heating connection is often used, as shown by the dotted lines in Fig. 295. This form of connection consists in running the flow pipe from the range, up and into the flow pipe from the boiler, and taking a branch from this line into the side of the boiler. This plan can be used to advantage, as it gives a quick supply of hot water, and storage is made through each connection. Another means of obtaining a quick supply of hot water is by the use of a gas heater, as shown in Fig. 297.

Gas heaters are made in a great variety of styles, and by many

manufacturers, and are used extensively, and to advantage. Many houses, apartment buildings, etc., are now being built with the kitchen heated by the house-heating system, and therefore requiring no coal range for heating purposes, the cooking being done on a gas range. Under these circumstances, the use of an auxiliary heater is of great advantage. It is usually provided with

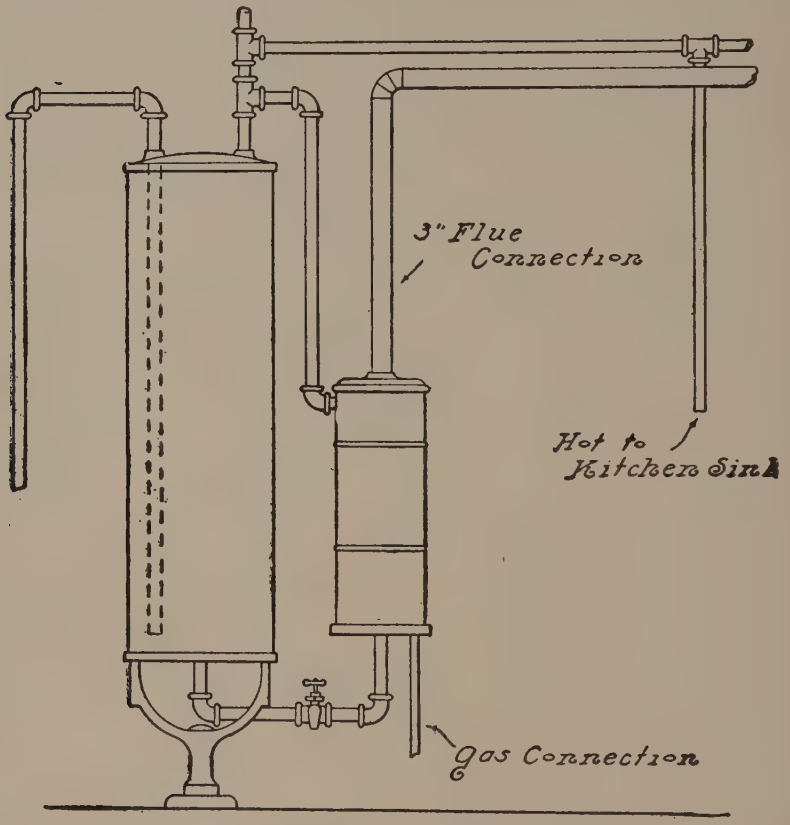


Fig. 297.—Connections for Auxiliary Gas Heater.

a quick-heating connection, as shown in the illustration, from which hot water can be quickly obtained, without heating up the entire body of water in the boiler. Under almost any circumstances, the auxiliary gas heater may be used to advantage in the summer season, when it is undesirable to heat up the rooms of the house by running the kitchen range. The gas heater should

be connected to the kitchen chimney by means of a 3-inch smoke pipe. Instantaneous gas heaters may be used to advantage in bath rooms, without the use of a boiler for storage purposes. As their name implies, some makes of these heaters will produce a supply of hot water almost instantaneously, making them very convenient for bath and lavatory purposes under various conditions.

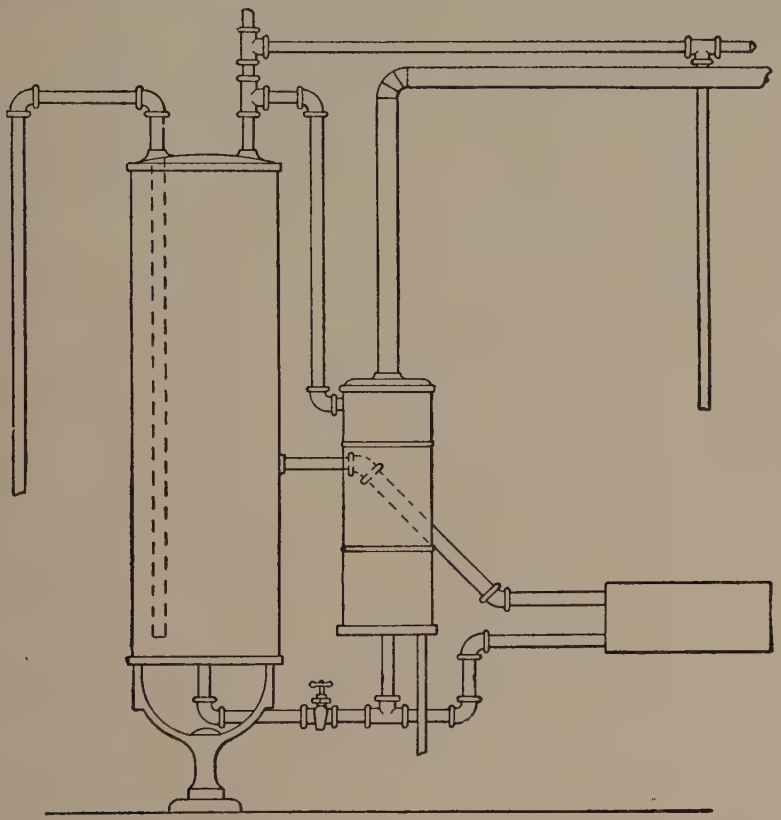


FIG. 298.—Range Boiler Heated by Kitchen Range and Auxiliary Heater.

In Fig. 298 is shown another very common scheme of connections, in which the gas heater is connected to deliver hot water quickly, and the kitchen range connected in the ordinary manner, the latter being depended on to produce a storage of hot water in the boiler. The cold-water connection to the gas heater is taken out of the return to the range. This combination of connections

may also be used to advantage when the auxiliary gas heater and the gas range instead of the coal range are used. The gas range may be provided with a water front, and connected to the range boiler with as satisfactory results as the regular kitchen range. It is often required to connect a range boiler and range when the two are on opposite sides of a door. The correct method of performing the work is to be seen in Fig. 299. It is obvious that to connect the flow pipe from the range into the side of the boiler

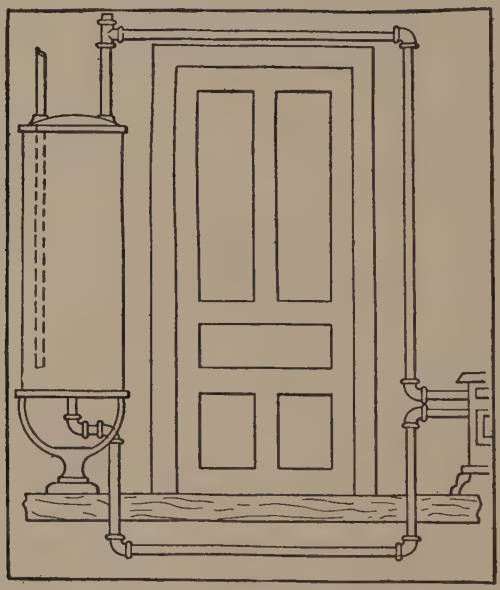


Fig. 299.—Boiler Heated by Range with Door Between. Correct Method.

in the ordinary manner, would be an impossibility, as it would have to pass across the doorway. Noting this fact, the uninformed workman will sometimes attempt to solve the difficulty by carrying the flow pipe down and under the floor, and then vertically into the side of the boiler, as in Fig. 300. This is clearly wrong. A trap is formed, and in order to carry hot water through it, it must be forced, for it will never circulate in the natural way. The correct method of Fig. 299 will avoid such difficulties, and will perform the required work in a proper manner. It will be observed that the proper solution of this problem is nothing more nor less than the use of a quick heating connection, fully described

above. Another very similar problem is that in which the range and boiler are in adjoining rooms. The same means are employed in making proper connections, as will appear from Fig. 301.

The connection of the range boiler to a range on the floor below it, is a connection often called for, such a connection being shown in Fig. 302, from which it will be seen that no different principle is involved than in the work on an ordinary range connection. The location of the range boiler on the floor above the range often comes from the use of the former to heat a bath room, which it can

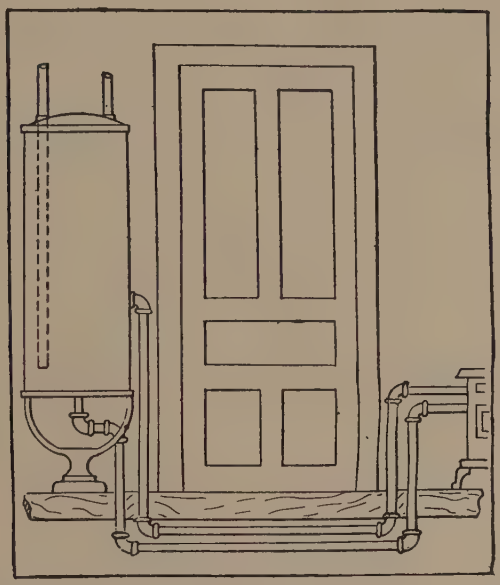


FIG. 300.—Boiler Heated by Range with Door Between. Wrong Method.

usually do very successfully. When the bath room is located adjacent to the kitchen, and on the same floor as the boiler, the latter may often be located in the bath room, and its heat used as a means of heating the room. These conditions often exist in flat houses.

One of the most common range-connection problems is that of heating a boiler from two ranges, one being on the same floor as the boiler, and the other on the floor below. The problem often appears also, where a laundry stove in the basement is to be utilized, or

a coil in the furnace required to give additional heat to the boiler. Connections under these conditions should generally be made in such a manner that the boiler may not only be heated from both sources of heat, but also by either source alone. There are several methods by means of which this work may be successfully performed, four of which are shown in Figs. 303, 304, 305, and 306. It is well to state in this connection that on such problems as this one the use of valves to control the heating from the two sources of heat is not in general a wise course, as they must necessarily

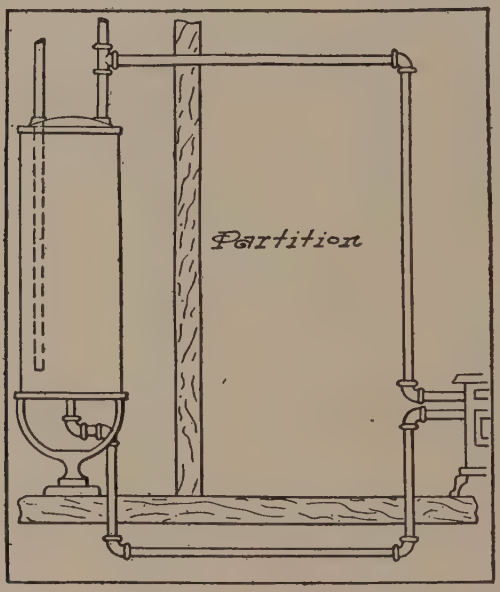


FIG. 301.—Boiler Heated by Range in Adjoining Room.

be controlled by people not familiar with such matters, and the wrong use of valves sometimes leads to disastrous results. While either of the four methods mentioned will accomplish the desired results, it is natural that there should be a preference in selecting the method to be used. Method No. 1, shown in Fig. 303, is perhaps the most natural and simplest, and therefore the method most commonly employed. It is true, however, that this method is not considered the most satisfactory. In the No. 1 connection the flow pipe from the upper range is connected into that from

the lower range, and there is danger that the flow of hot water from the lower range will in a measure obstruct the free passage

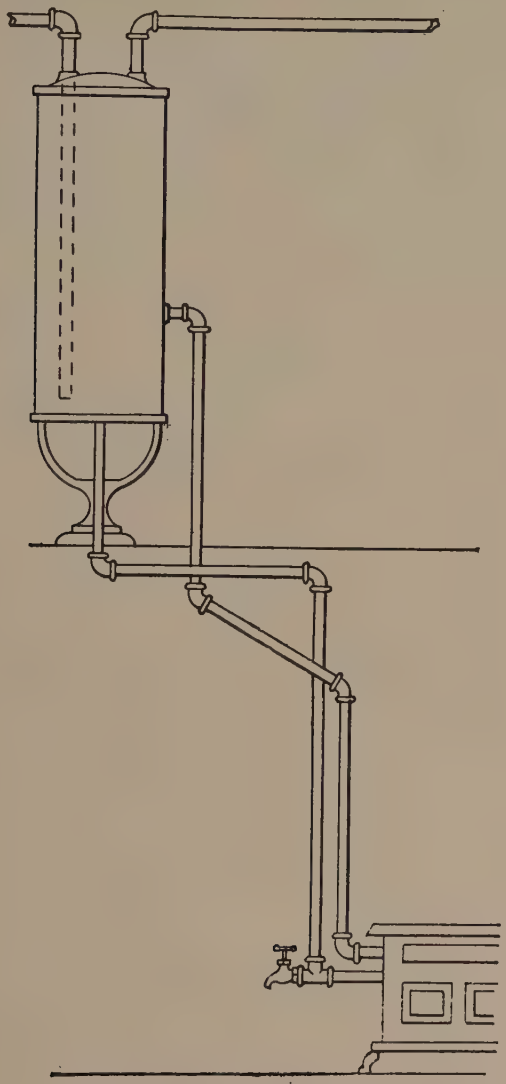


Fig. 302.—Range Boiler Heated by Range on Floor Below.

of hot water from the upper range. If the water issuing from the lower range happens to be heated to a higher degree than that from

the upper one this trouble is increased, the result of such conditions not only being seen in decreased efficiency, but it is also liable to result in hammering, which is always a disagreeable feature.

Method No. 2, Fig. 304, avoids the difficulty found in No. 1,

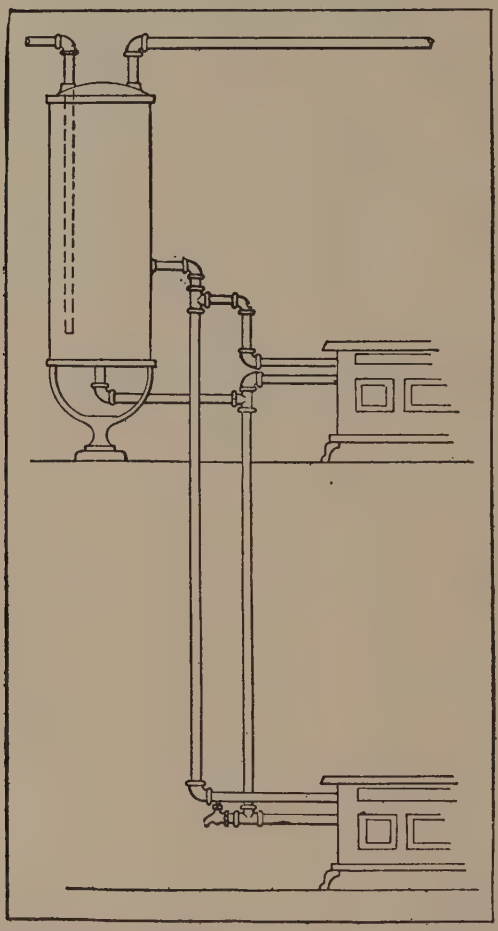


FIG. 303.—Range Boiler Heated by Two Ranges on Different Floors. Method No. 1.

the two circuits being entirely separate. The only arguments against No. 2 are that in order to use it a boiler must be used which is not commonly to be found, and that a somewhat greater amount of pipe is required, although the latter objection is comparatively insignificant.

The system shown in Fig. 305, method No. 3, is probably the most satisfactory of the four systems shown. This method provides a direct line of circulation, with no obstructions, and with the least possible amount of pipe, the latter feature having the

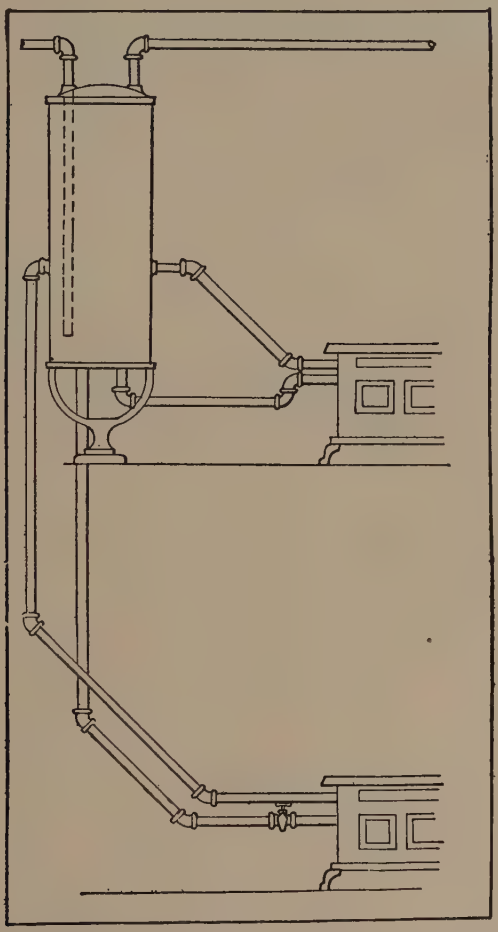


FIG. 304.—Range Boiler Heated by Two Ranges on Different Floors. Method No. 2.

advantage of presenting the least amount of surface to cool the hot water in its passage to the boiler. When either range is not in operation there is nothing to prevent the heating of the boiler by the other. Method No. 4, Fig. 306, is also to be considered

a very effective one, and is in many cases preferable even to No. 3. According to this method, the connection from one of the ranges should be a quick-heating connection. Either one of the ranges may be thus connected, according to circumstances.

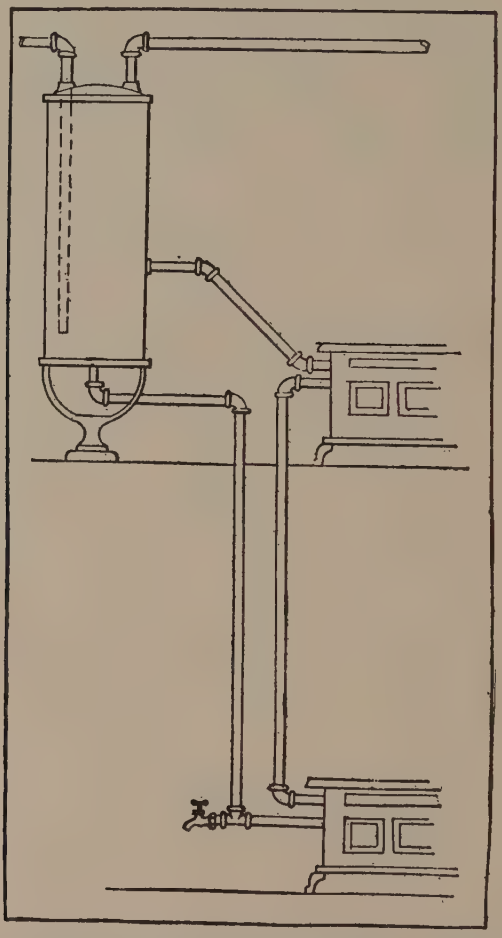


FIG. 305.—Range Boiler Heated by Two Ranges on Different Floors. Method No. 3.

Another problem, one with which the average plumber is generally unacquainted, consists in heating a range boiler on the floor below that on which the range is located. In considering this problem, it may be stated at the outset that the conditions are

entirely unnatural, for it means that hot water must flow downward from the range to the boiler, whereas the natural course is an opposite one. As a consequence, the heating of a boiler under these conditions must not be expected to be accomplished with

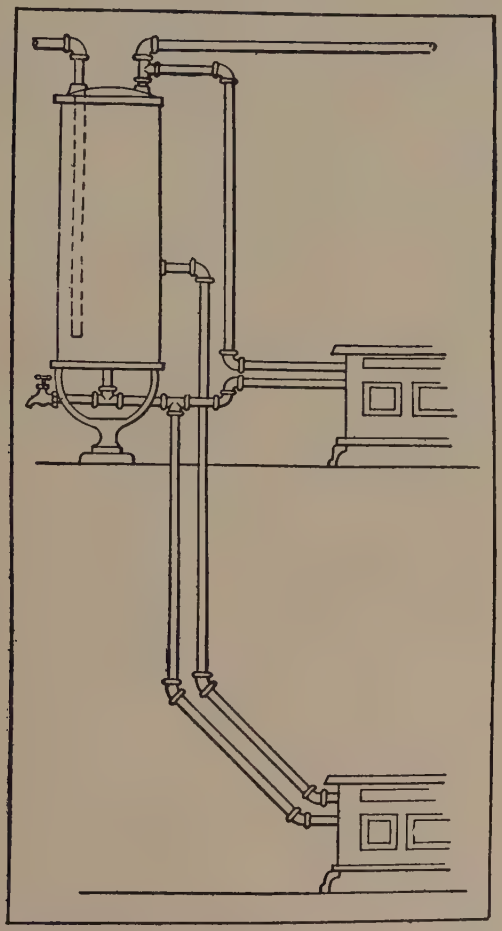


Fig. 306.—Range Boiler Heated by Two Ranges on Different Floors. Method No. 4.

anything like the same degree of efficiency that is to be obtained under natural conditions.

To obtain any results whatever, it is necessary on such work as this to run the flow pipe vertically above the range, usually to

the ceiling, from which point it is then carried down to the top of the boiler and connected, as appears in Fig. 307. If the flow pipe can be run higher than to the ceiling—to the ceiling of the

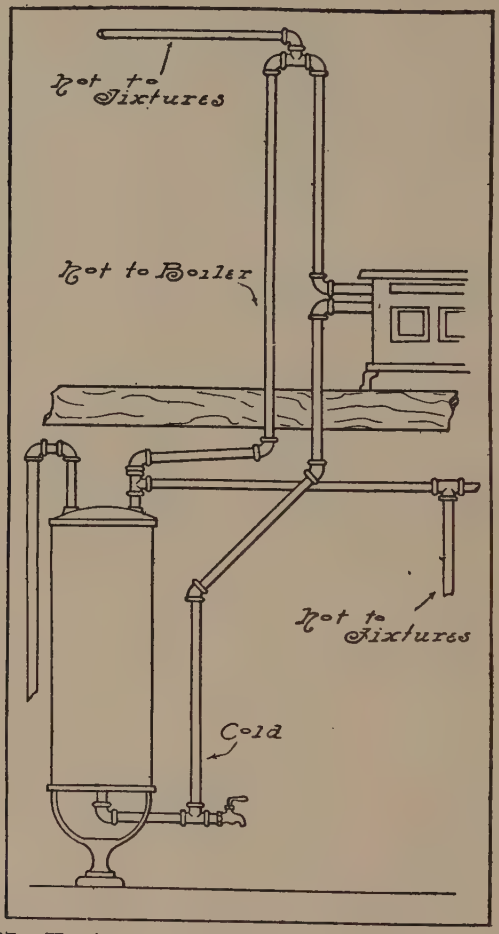


Fig. 307.—Heating of Range Boiler on Floor Below Range.

next floor above, for instance—the results obtained will be so much the better.

In carrying the flow pipe vertically through the greater distance, it is given more opportunity to cool, and therefore falls to the boiler more readily. A difference in temperature is necessary in all circulation work. The greater vertical rise of the flow pipe

also gives a greater weight of water, which is essential in systems of this nature. By means of the method shown in Fig 307, a storage of hot water can usually be obtained, sufficient in amount if the demands upon the boiler are not too great. The chief

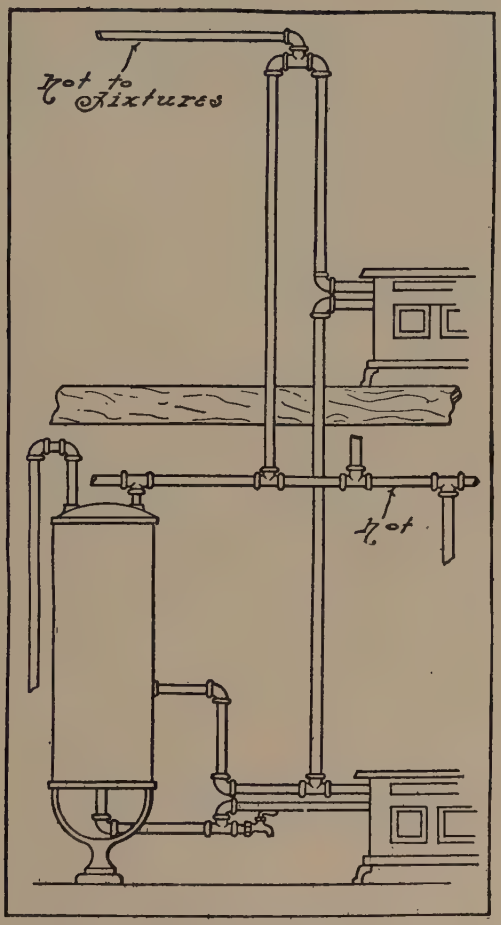


Fig. 308.—Boiler Heated by Range on Same Floor and Range on Floor Above.

difficulty in connection with the proper solution of this problem is the collection of air at the top of the loop. Unless provision is made to relieve this air, it will very quickly make the system inoperative.

If there are fixtures on the floor above the range, the remedy

is easily applied by taking a supply pipe from the top of the loop to some fixture that is in common use, as, for instance, a bath-room lavatory. If the system is under tank pressure, of course the expansion pipe from this high point will do the work. If, however, the system is under direct pressure, and there are no third-floor plumbing fixtures, the relief of the high point cannot be accomplished in a satisfactory manner. The only thing that can be done under these circumstances is to place a pet cock at the high point, by means of which the air may be relieved when necessary by opening it by hand. Since this method is not automatic, it is open to strong objection, and the only way in which it may reach any degree of satisfaction is to see to it that some one opens the valve at frequent stated intervals. A drip pipe to the sink should be run from the pet cock. Another way in which this problem sometimes presents itself is to be seen in Fig. 308, where not only a range above the boiler, but also a range on the same floor as the boiler is to be used. This problem is not so common as the previous one, but sometimes occurs when the boiler must for some reason be located in the basement, and it is required to heat it from the laundry stove in the basement and the kitchen range on the first floor. The best feature about these circumstances is that when the greatest amount of water is required—that is, for washing purposes—the laundry stove, which is connected in the ordinary manner, will be in operation, and will usually be able to provide amply, whereas it would be difficult often to get a sufficiently abundant supply from the upper range. The work shown in Fig. 308 does not bring in any features different from those encountered in the preceding problem.

CHAPTER XXVI

HOT-WATER SUPPLY FOR OFFICE AND APARTMENT BUILDINGS, ETC.

The principles governing hot-water supply are naturally the same, whether it be in relation to small residence work or to the more extensive systems of large buildings.

In the latter work there is not only a much larger quantity of water to heat and distribute to various parts of the building,

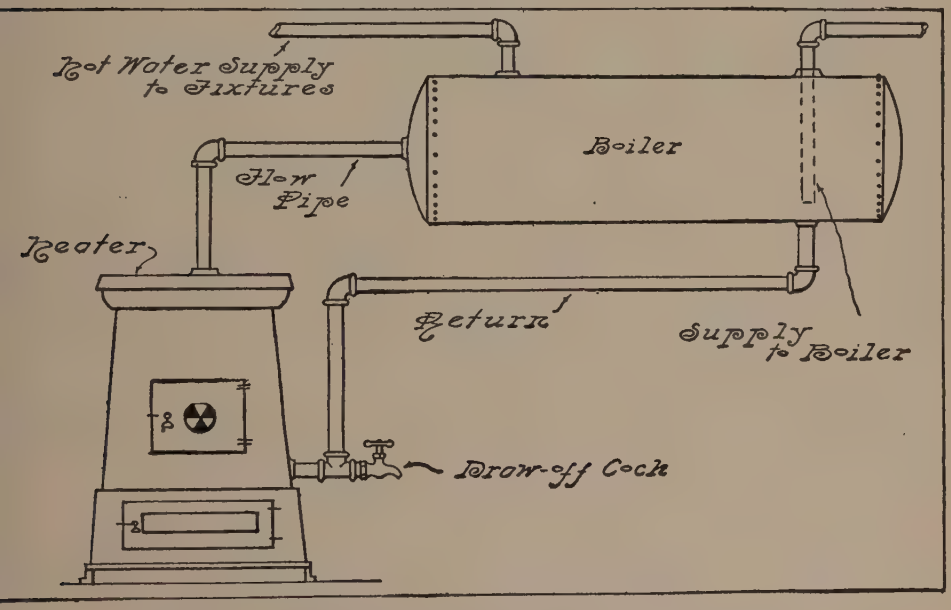


Fig. 309.—Connections for Horizontal Boiler and Tank Heater.

but, owing to the fact that there are often in these buildings hundreds of people making use of hot water, the perfect and continuous operation of the system becomes a necessity. This makes it necessary that the piping be run on correct principles, and that mains and branches be of sufficient capacity to properly perform

their work. On small hot-water systems a serious error may not prevent the furnishing of hot water after a certain fashion, serving only as a matter of inconvenience to a few, while the same error on large work would produce great inconvenience to a very large number of people.

Hot water is generally furnished to large buildings by a special heater, such as shown in Fig. 309, located in the cellar or basement and connected to a large hot-water tank, which may be of the horizontal type, as in the above-mentioned illustration, or of

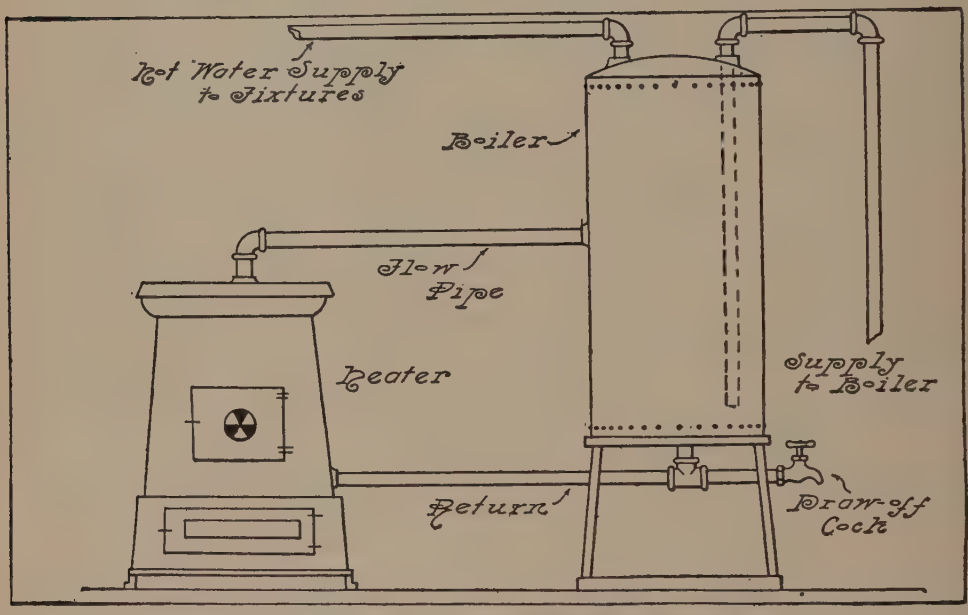


Fig. 310.—Connections for Vertical Boiler and Tank Heater.

the vertical type, as in Fig. 310. The horizontal tank hung from the cellar timbers is the more generally used of the two types, the principal reason being that it is less in the way than the vertical tank. As far as the connections between heater and tank are concerned, they are similar to those of the kitchen range and boiler, and therefore whatever has been stated concerning the latter applied to the former also.

In addition to the use of water heaters for tank heating, live and exhaust steam are also used, in connection with steam coils

inside the hot-water tank, as in Fig. 311. An advantage gained by this method is that during the winter season, when the heating plant is in operation, the tank may be heated by means of the coils without using the tank heater, while during the summer months the latter may be used.

Coils are often used to provide additional heating surface, when sufficient hot water cannot be secured by use of the tank heater alone.

The proper method of supporting horizontal boilers is shown in Fig. 312. This consists in the use of heavy, wrought-iron

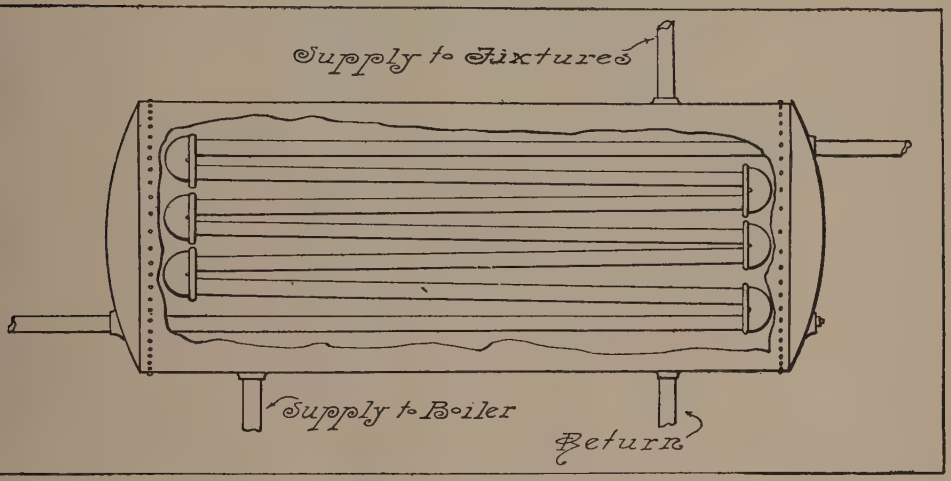


Fig. 311.—Hot Water Boiler Heated by Steam Coil.

hangers at each end of the boiler. These hangers pass around the boiler, taking the weight of it, and being securely fastened to the cellar timbers.

In Fig. 313 is shown a hot-water supply system for a large building, working under tank pressure. A tank system has the advantage of delivering water under a constant pressure, while the direct-pressure system varies considerably.

A varying pressure is not only an annoyance, but it is hard on the valves and piping. As explained in another chapter, the direct-pressure boiler is liable to siphonage, while the boiler working under tank pressure is not.

The main flow pipe in Fig. 313 is carried directly to the highest point, and thence horizontally to a second vertical line of fixtures, dropping down from this point and returning to the heater, thus forming a complete circuit.

It will be seen that the piping constantly rises to the high point where the expansion pipe is connected. When the water has traveled thus far from the heater it has begun to cool, and falls through the second vertical line back to the boiler, but being

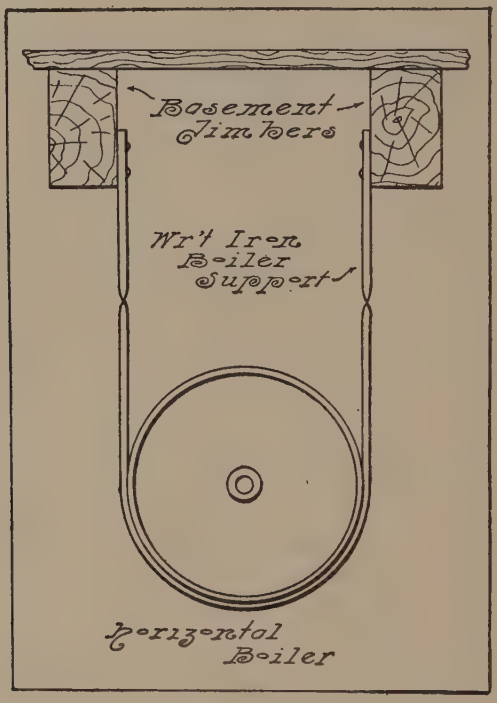


Fig. 312.—Supporting of Horizontal Boiler.

sufficiently hot to supply the fixtures on this line with hot water. The rising of the hot water and falling of the cooler water continues without interruption so long as the water is being heated, and constitutes what is known as circulation.

The expansion pipe from the high point is a necessity on the tank system of supply, not only to vent the system in case the water becomes overheated, but to relieve it of air, thus preventing

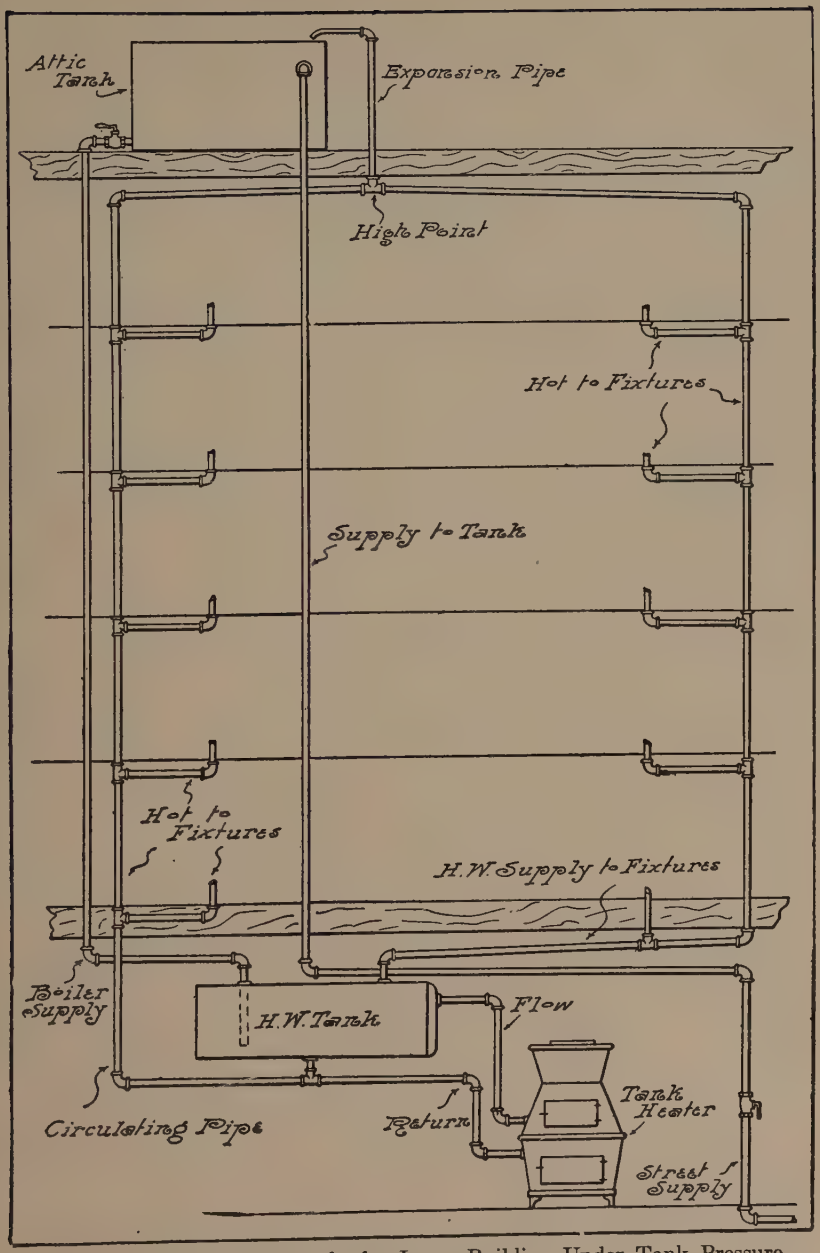


FIG. 313.—Hot Water Supply for Large Building Under Tank Pressure.

air-lock, which is often the cause of the inability of the hot-water system to work properly. The attic tank is generally supplied by direct pressure. When the direct pressure is not sufficiently high in the case of high buildings, the water lift is often made use of. A description of the water lift and its action, as well as descriptions of several systems on which it is used, may be found in the following chapter.

In Fig. 314 a system of hot-water supply known as the overhead system is shown, in some respects similar to the work illustrated in the preceding figure.

This system in the present case is under direct pressure. The overhead supply system is similar in principle to the overhead heating system, and wherever it is possible to install it, may be depended upon to give fully as good results as any other system.

When such a system is under direct pressure, the expansion takes place back through the supply pipe to the boiler and thence through the street mains to the source of supply. Owing to this fact, it is not generally necessary to run an expansion pipe if it were not for venting the system of air. Such a pipe, as seen in Fig. 314, is generally connected to an expansion tank, and an overflow from the tank onto the roof.

In the overhead system, as in the system of Fig. 313, the main flow pipe runs as directly as possible to the top floor, and then is run horizontally, drop risers being taken out wherever required, these pipes entering a main return in the basement, which carries the return water back to the boiler, the drop risers thus doing the work of flow and return. This system probably provides more evenly heated water than most other systems of supply.

A third hot-water supply system for large buildings is shown in Fig. 315, this system differing considerably from those already shown. The main flow pipe is carried from the boiler to such points as vertical risers are to be supplied, the main pitching upward from the boiler. These risers should connect at the top into a main horizontal line, to which a main vertical return connects, through which the water is carried back to the boiler. An automatic air valve should be placed at the highest point on the piping, to relieve the system of air-lock. On each vertical line, as shown, there should be a valve, by means of which the circulation of hot

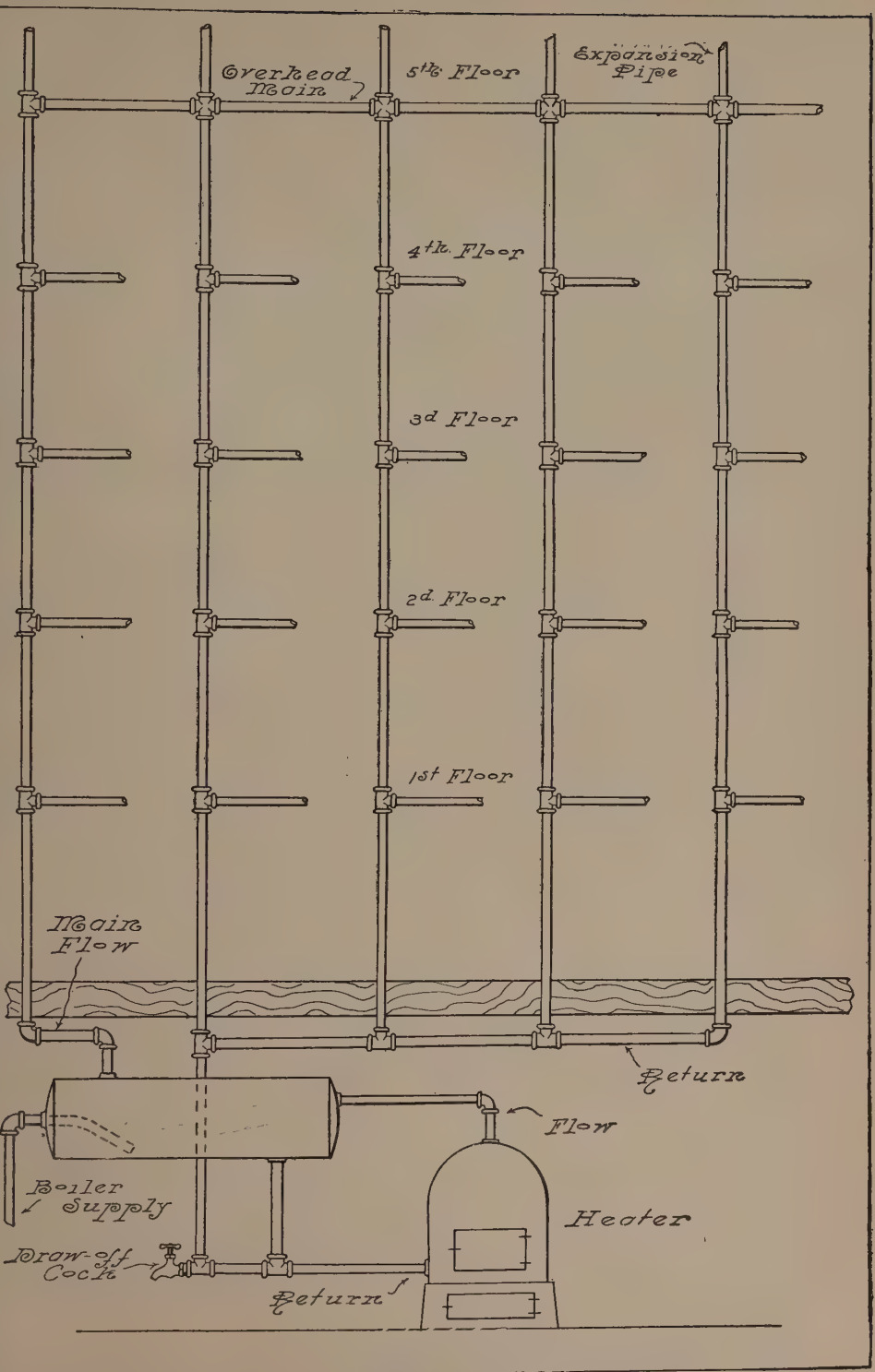


Fig. 314.—Overhead System of Hot Water Supply for Office or Apartment Building.

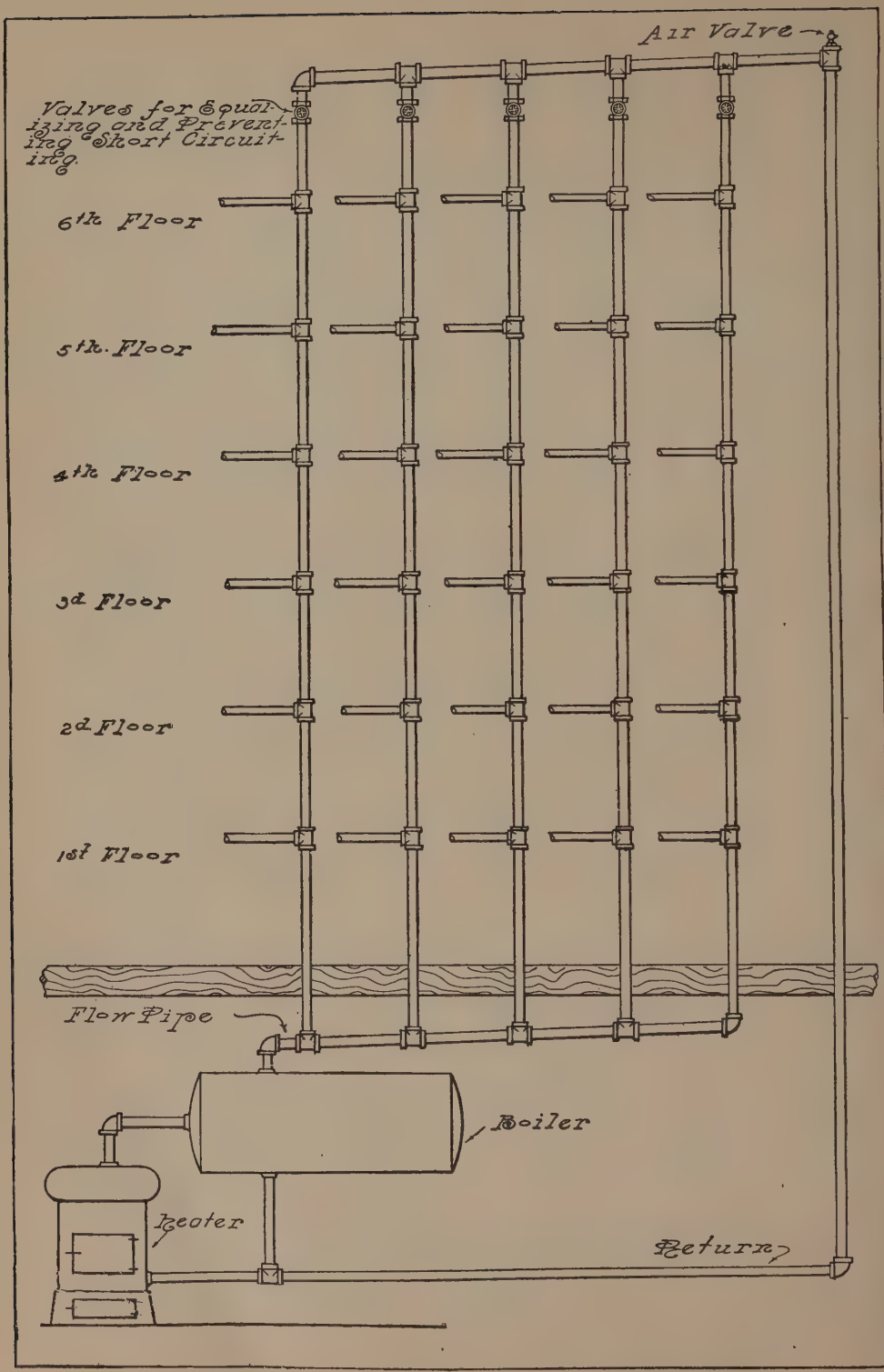


Fig. 315.—Hot-Water Supply for Office or Apartment Building.

water may be equalized, in order to prevent different parts of the system from taking too large a share of hot water, to the detriment of other parts of the system.

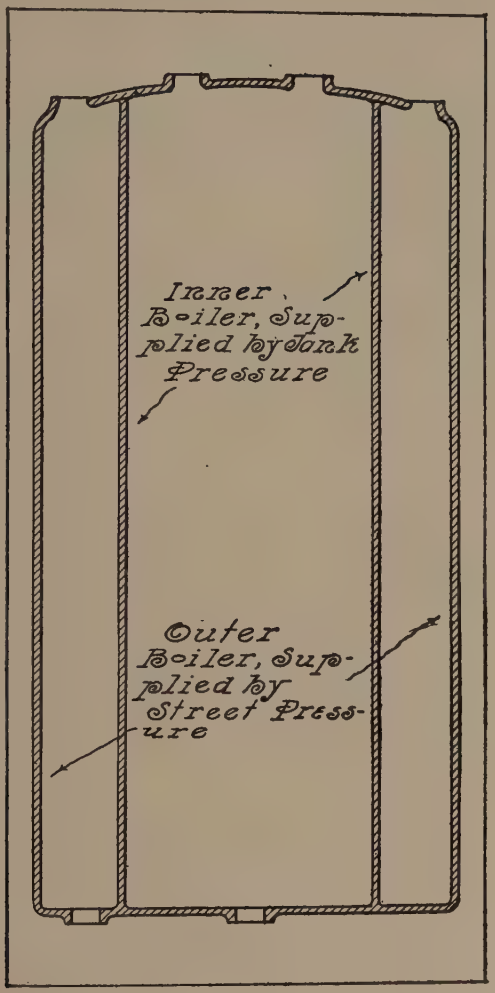


Fig. 316.—Section of Double Boiler.

In selecting the proper system of hot-water supply for a large building, as much judgment is needed as in the selection of the proper system of heating.

While one system under certain circumstances and conditions

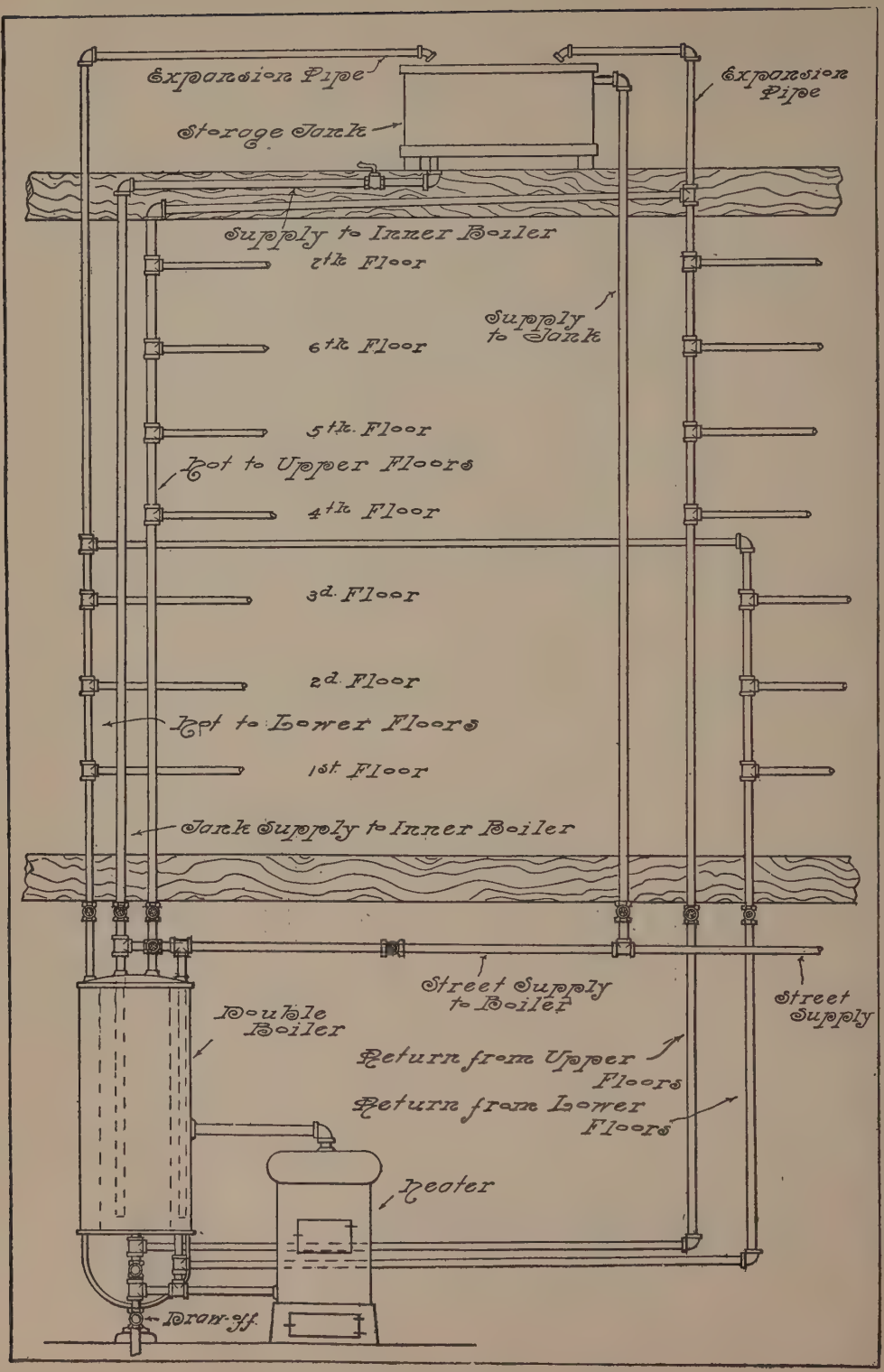


FIG. 317.—Hot Water Supply from Double Boiler.

will perform excellent service, another will fail entirely. If the plumber is well grounded in the principles of circulation, and a man of practical experience, he will usually be able to determine what system of supply under the given conditions will give the best results.

The double boiler is a device which finds an important application in the hot-water supply systems of many high buildings in the large cities. It is very seldom used, however, in any but the largest cities.

In Fig. 316 is shown a sectional view of the double boiler,

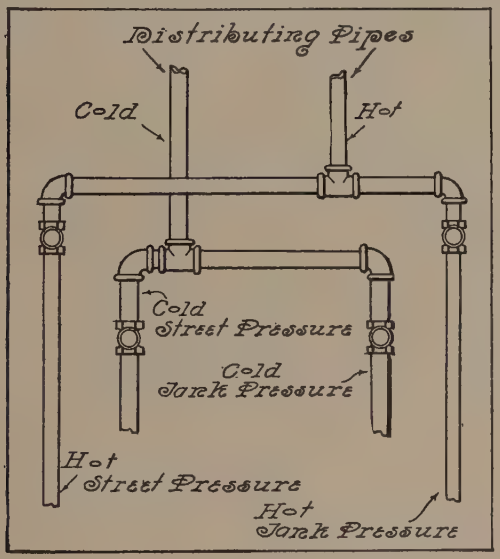


Fig. 318.—Simple Form of Cut-off.

from which it will be seen that it consists of two boilers, one inside the other. The outer boiler is heated in the usual manner, and the inner boiler is heated by contact with the heated water of the outer boiler. The outer boiler is under direct pressure, and the inner boiler under tank pressure. It will be readily considered that in high buildings, running up many stories, the upper floors are sometimes above the height at which water under city pressure can reach. Even though this condition is not permanent, it often happens that during certain times of day the

pressure which at other times is sufficient is so reduced that it cannot force water to the higher floors. It is under these conditions that the double boiler is made use of, as shown in Fig. 317.

The inner boiler supplies hot water to the upper floors under tank pressure, and the outer boiler supplies the lower floors under street pressure.

The attic storage tank must generally be supplied by means of a pump or water lift.

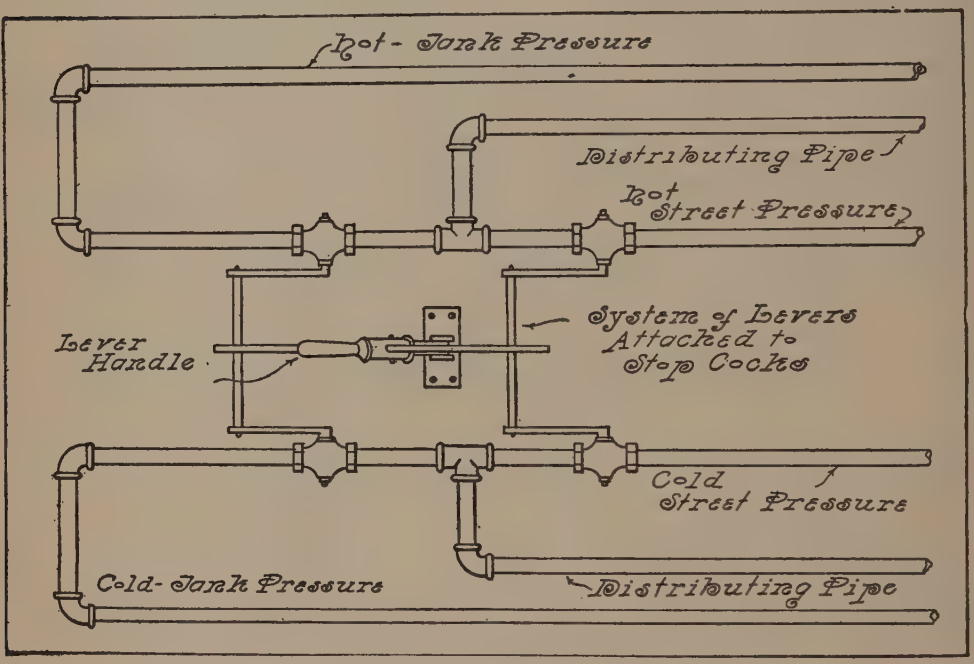


Fig. 319.—Automatic Cut-off.

The cross connection between the two boilers allows both to be fed with street pressure when the latter is high enough to reach the upper floors. At night when the pressure is high, this course may be adopted, thus saving the expense of pumping to the tank.

In Fig. 318 is shown a simple form of cut-off, a device often employed on double boiler work for the purpose of delivering into the distributing pipes a supply of water under either tank pressure or direct pressure, as the case may be.

The successful operation of this cut-off is entirely dependent on the attention and caution of the attendant in the opening and closing of the proper valves, and the occasional lack of care has resulted in casting this device away for automatic cut-offs, such as the one of Fig. 319.

In the latter, each of the four valves is rigidly attached to a system of levers, operated by a handle, the throwing of which either opens or closes the proper valves, thus obviating any mistakes.

The same work that is accomplished by the double boiler may be performed by two single boilers connected in the proper manner, as seen in Fig. 320.

In order to run the two boilers under different pressures the water front of each must be entirely separate from that of the other. Separate coils in the same heater may be used for this purpose. Special heaters having two separate heating surfaces may also be used. The general connections for this system are quite similar to those of Fig. 317. One boiler supplies the upper floors, and is therefore under tank pressure, while the other supplies the lower floors under street pressure.

It may be stated that double-boiler work is taken up by the author in his work entitled " Modern Plumbing Illustrated."

A very common difficulty that is encountered in many sections of the country, especially in the West, is the accumulation of lime in the range connections and piping. This trouble is serious enough in connection with the procuring of hot-water supplies for residences and dwellings, but in the case of larger work, such as public or semipublic buildings, its existence results in much greater annoyance.

In some localities the only natural supply of water that can be obtained is hard water, strongly impregnated with lime, which it takes up in its passage through the soil. The depositing of lime takes place principally in hot-water pipes, although it also occurs in the cold-water pipes. When the lime has once begun to accumulate on the interior of a pipe, the accumulation increases rapidly, and often in a comparatively short time the pipe will become entirely filled. This condition is not only a source of much annoyance, but a source also of danger.

Many attempts have been made to clear pipes thus filled with various substances, but even though sometimes partially successful, such a cure does not produce permanent results. It is usu-

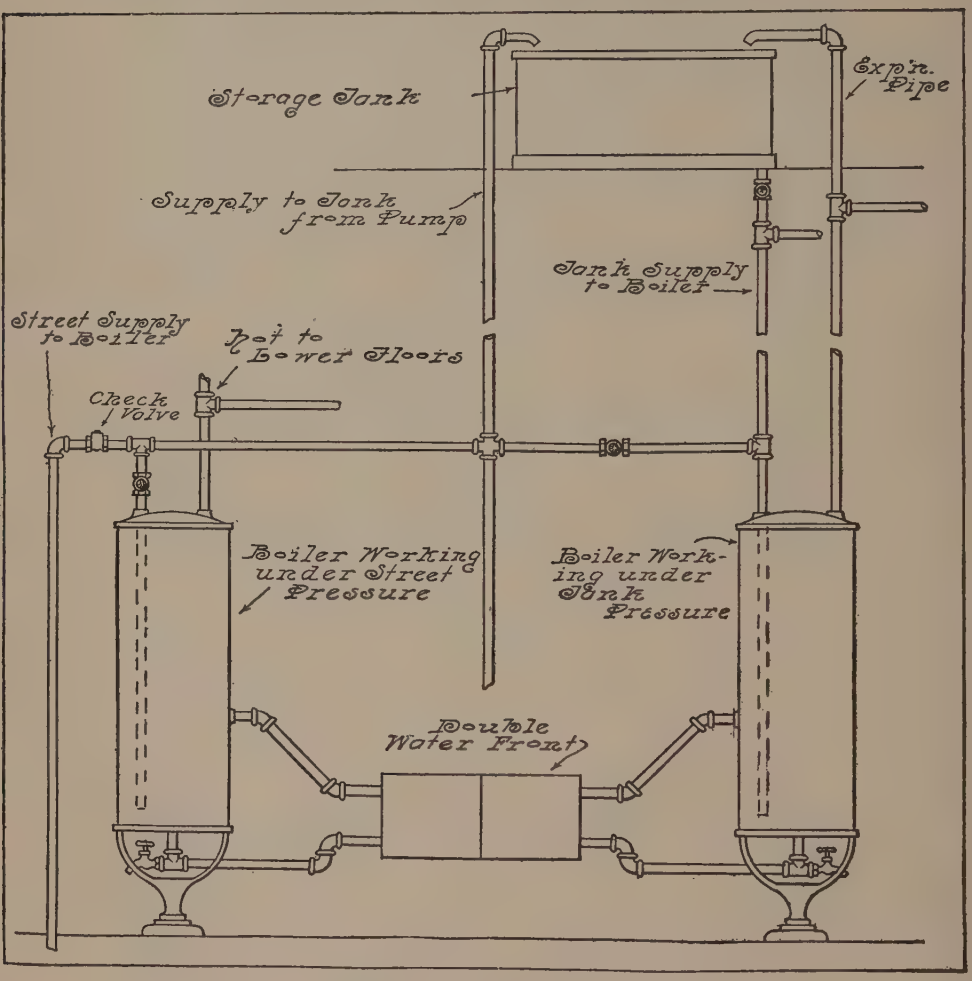


Fig. 320.—Two Single Boilers Doing Work of Double Boiler.

ally more satisfactory to replace the filled pipe with new pipe rather than to attempt to clean out the lime deposit.

Acids act on such deposits, as also caustic soda, but they constitute a harsh remedy, capable of doing harm as well as effecting the desired remedy.

Special patented devices for attachment to the range connection may be procured, which are claimed to prevent the choking of the pipes with lime.

It would seem, however, that these various devices and recipes were not along the proper lines, and that a much better plan would be to prevent the entrance of the impregnated water into the range connection, where most of the trouble from accumulation of lime occurs. Fig. 321 illustrates a method of this nature. According to this plan, two attic tanks are used, a small tank for rain water and larger tank for the hard water of the natural supply. It will be noted that no range boiler is used.

A down supply line from the rain-water tank is connected directly to the water front, the flow pipe from which is carried up to the hard-water tank and connected to a heating coil located in the latter. After passing through this coil, the water passes back to the rain-water tank. This constitutes a complete system of circulation for the heating of the contents of the hard-water tank by means of the coil, the work being done by water free from lime, and thus avoiding the deposit of lime in the range connections. From the hard-water storage tank a line of hot-water supply is taken down to the various fixtures. It is an excellent plan to place blocks of limestone on the heating coil in the hard-water storage tank, as the lime in the water will deposit on such blocks in preference to the piping or sides of the tank. The use of these blocks will therefore aid greatly in keeping the tank and piping free of lime. If limestone is not at hand, oyster or clam shells will do the work. Shells placed in a tea kettle in which hard water is used will prevent the accumulation of lime inside.

While the method just described is the most effective one that has yet been suggested, there are two objections connected with its use that should be mentioned. In the first place, if the hard-water storage tank is open it cannot be made to heat to so high a temperature as the range boiler, owing to the escape of heat from the exposed surface. In the second place, more or less steam must inevitably escape into the air, and in many cases this feature would be objectionable. Without doubt, however, the tank could in most cases be heated to a sufficiently high temperature for all ordinary purposes.

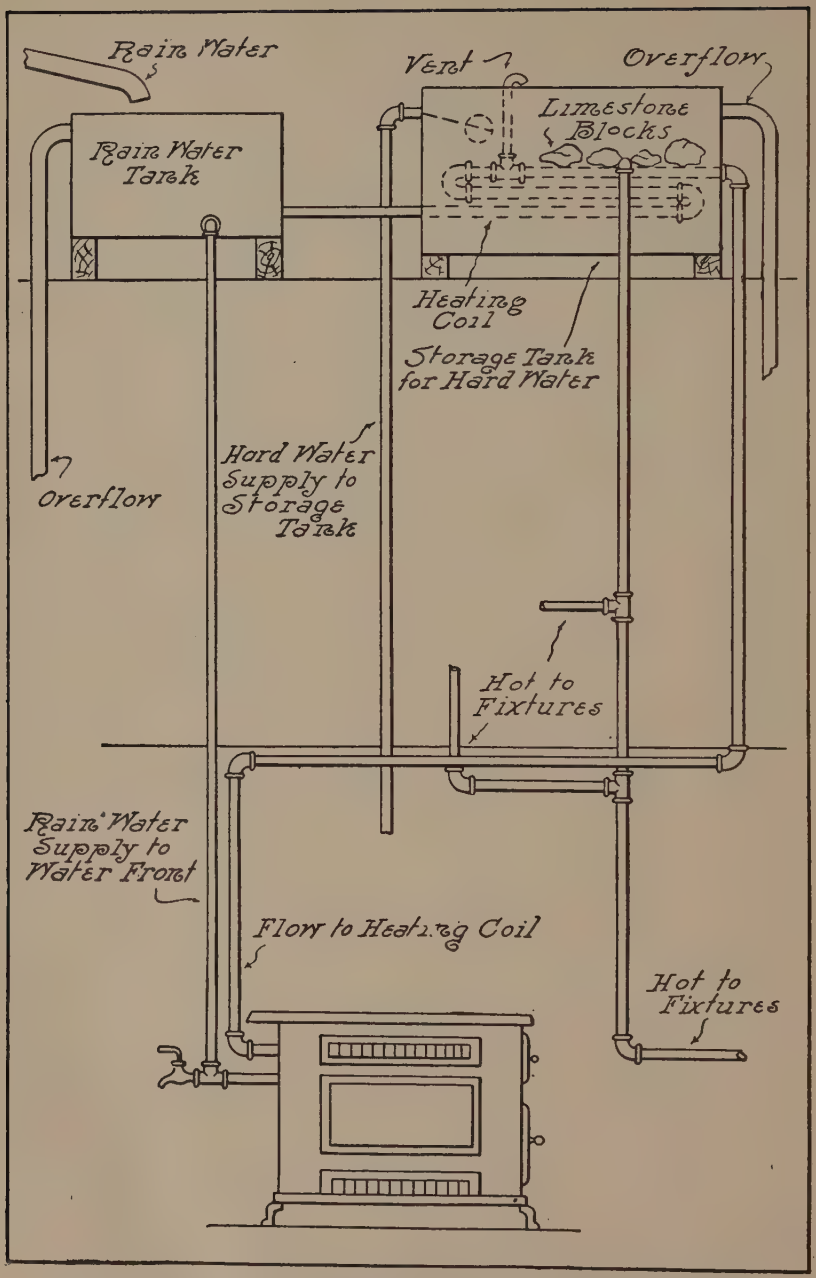


FIG. 321.—Method of Preventing Deposit of Lime in Range Connections.

There is no reason, however, why this tank cannot be sealed over, with a vent taken through the roof, which would in a large measure free it of its objectionable features.

Another method of preventing lime deposit is to use a range boiler having a coil, the water front being connected direct to the coil, but not otherwise connected to the boiler. The water front should be supplied with rain water, and from the high point on the flow pipe an expansion pipe should be carried to the tank.

CHAPTER XXVII

THE WATER LIFT AND ITS APPLICATIONS

As generally considered, the water lift finds its principal application in city work, but may also be used to great advantage in the country, and in connection with institutions, manufacturing plants, etc., that have their own private systems of water supply. In Fig. 322 is to be seen a sectional view of a successful type of

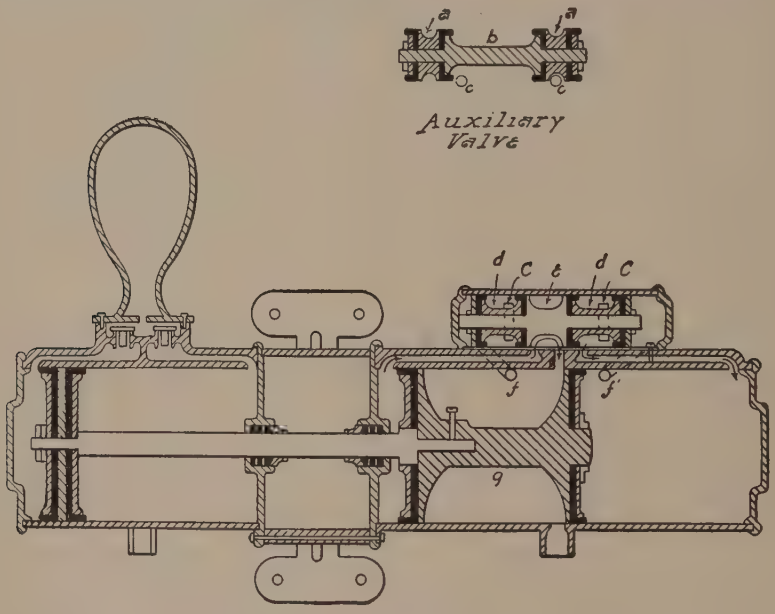


Fig. 322.—Sectional View of Water Lift and Auxiliary Valve.

water lift, and of its auxiliary valve. Owing to the position of the auxiliary valve, it is impossible to show it in a sectional view of the water lift, and therefore it is shown in a separate view.

Fig. 323 shows the connections for the water lift more clearly than the sectional view does. The water lift is operated by water pressure, and its action may be compared to that of the steam

engine, water pressure taking the place of steam. Fig. 323 shows that there are four pipes connecting with the water lift, including the connection with the water supply, the suction pipe into the body of water to be lifted, the discharge pipe from the lift to supply the fixtures, and the waste. The latter should never be connected directly into the drainage system, but may be indirectly connected. The water pressure which operates the lift, first passes into the auxiliary valve chamber, and into the space marked b, at

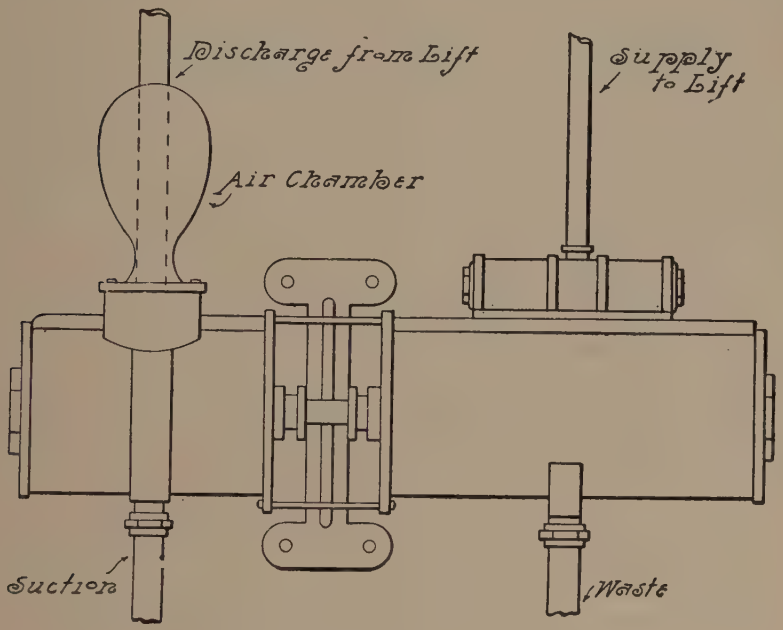


FIG. 323.—Connections for Water Lift.

either end of which is a leather cup. The main and auxiliary valves are separated by a wall, and connecting them are two openings c, c, cut through this wall. These passages connecting between the two valves are never closed, and consequently water always fills the chambers b and d, d. The chamber g is always in exhaust through the waste connection on the driving cylinder of the lift. As shown in Fig. 322, the pressure of the water on the piston head g has forced it to the left end of the driving cylinder. This pressure has been exerted by water entering on the rear

of the piston-head from the chamber d, through the port, as shown by the arrows. Chamber g is now exhausting into the exhaust chamber connecting with the waste, through the port in front of the piston head, which is connected to that chamber by the chamber e in the main valve. The construction and arrangement of valves is such that this exhaust takes place alternately, at either end of the driving piston. Having thus shown the manner in which pressure water is admitted to the driving cylinder, and exhausted from it, the operation of the valves should be considered. The two valves, main and auxiliary, are set parallel to each other. A small opening is made into the driving cylinder from the auxiliary valve chamber, and at each end of it, as shown by f and f. In the chamber b of the auxiliary valve, are two passages, c, c, which connect into the space in the cylinder of the main valve, which is between the valve head and the cylinder head. The arrangement is such that one of the passages c, is alternately connected with the chamber b, the water of which is under pressure, while the other passage c is alternately connected with the exhaust passage a. In traveling to the left, the driving piston has uncovered the passageway f, and the pressure water enters the chamber of the auxiliary valve at its right end, thereby forcing the auxiliary valve to the left end of its cylinder. The other end of the cylinder is exhausting through f into the exhaust chamber g in the driving cylinder. When the auxiliary valve has traveled to the left, water under pressure passes from b through c into the space formed between the main valve and cylinder heads.

The pressure exerted on the main valve at its left end shifts it over to the right, and water under pressure from the chamber d at the left, passes into the driving cylinder at its left end, by way of the port leading into it. The driving piston is then forced to the right, uncovering f, and producing a series of operations similar to those just described. When the auxiliary valve shifts the pressure to either end of the main valve, the opposite end will be exhausting, and when the main piston brings the pressure on either end of the auxiliary valve, the other end will be exhausting. Because of this action, neither of the two valves meets with any resistance, and pressure water is against the main valve throughout its stroke. This makes it impossible for the lift to

become centered. In the illustration Fig. 323, the cylinder at the right is known as the driving cylinder, and that at the left as the suction cylinder. There is no connection whatever, between the two cylinders. Rigidly connected to the same piston rod, are the driving piston and the suction piston, each working in its own cylinder. The suction pipe is connected at the center of the suc-

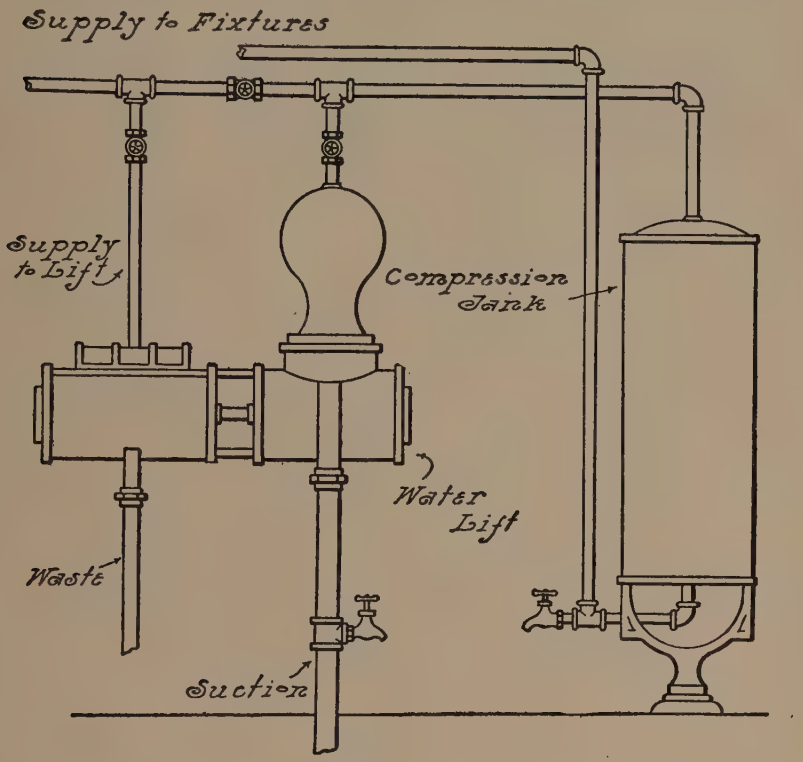


Fig. 324.—Water Lift Used on Direct Pressure System.

tion cylinder, and as the piston passes its entrance, a vacuum is created, which draws the water to be lifted, into the suction cylinder, from which, on the next stroke of the piston, it is forced up into the discharge pipe, two check valves holding the water as it is forced up. The air chamber prevents any shock due to the pumping.

There are various ways and various systems in which the water lift may be applied. Perhaps the simplest and most common

system on which it is used, is the one shown in Fig. 324. This is called the direct-pressure system. It may be operated in city or town work by means of the public water supply, and in country work by means of attic or windmill storage tanks. In this system, the water lift under street pressure, pumps filtered water or soft water, as the case may be, directly into the pipes supplying the fixtures.

An important part of this system is the compression tank. When water is pumped into the tank, it compresses the air in it, and whenever water is drawn at any fixture, the compressed air forces it out under pressure. Whenever the air in the tank becomes

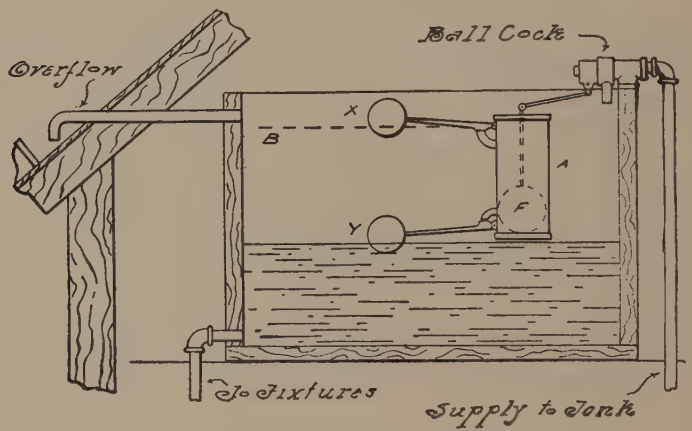


Fig. 325.—Automatic Storage Tank.

exhausted, it may be renewed by opening slightly the bibb on the suction pipe. Owing to the vacuum produced by the piston in the suction chamber, air will be drawn in and be delivered into the tank. In order that air may not be carried out more than possible when the tank is drawn upon, the supply to the fixtures from the tank is taken out of the latter at the bottom. The discharge from the lift into the compression tank is connected into the top of the latter. The use of the tank gives a steady stream and reduces the shock and hammering of pumping. By operating the valves on the cross-connection between lift and compression tank, water from the city mains may be delivered to the fixtures direct in the event

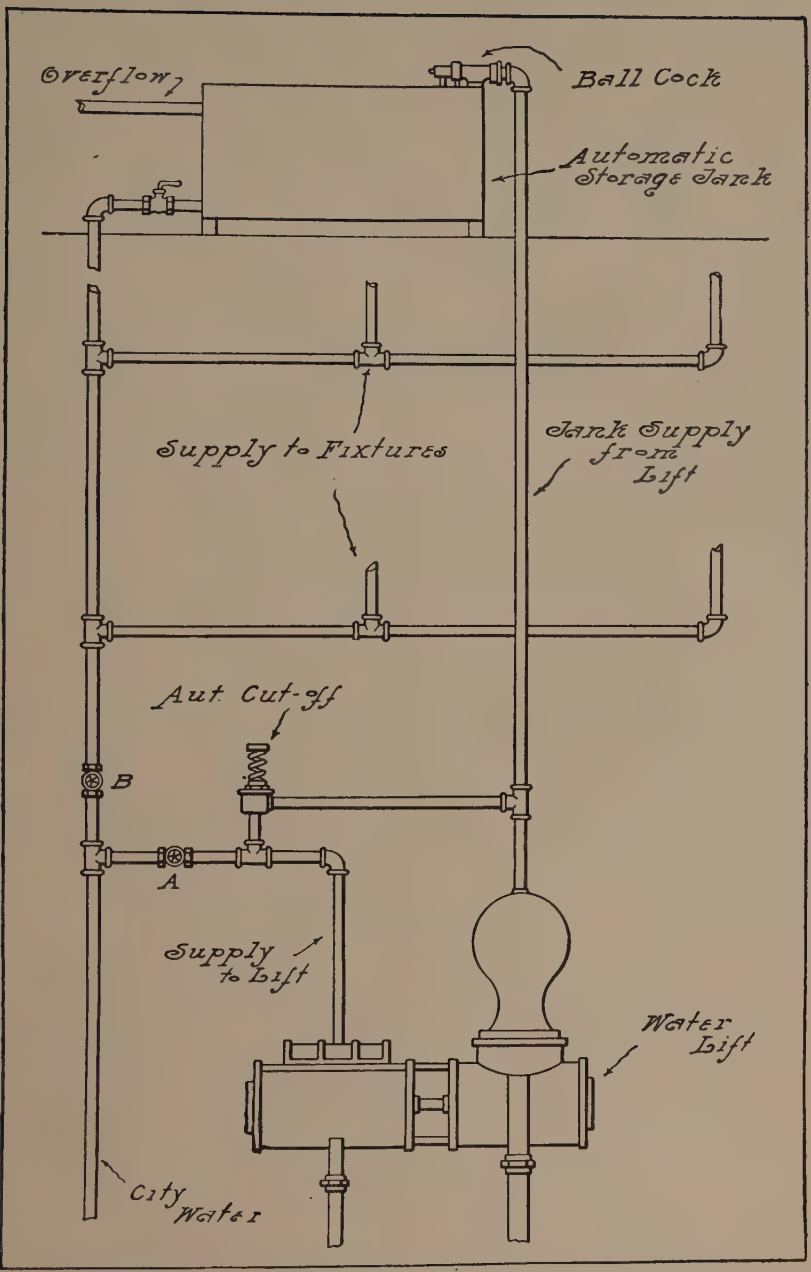


Fig. 326.—Water Lift Used on Automatic Storage Tank System.

that the soft or filtered water supply becomes exhausted. The water lift is now extensively used in connection with the automatic storage-tank system, which is often made use of in supplying soft or filtered water in large quantity. This system is shown in Fig. 324, and in Fig. 325 a sectional view of the automatic storage tank, the action of the latter being as follows:

This tank is supplied by the water lift through a ball cock whose float works in a cylinder A, of small size, placed inside the storage tank. Two other floats, X and Y are connected by a lever seating arrangement to two openings into the top and bottom of the cylinder F. Whenever the water falls below the level slightly above C, the float Y falls and opens the lower opening, through which the water in A escapes, causing the float F to drop, this action causing the ball cock to open, and also relieving the pressure on the cut-off shown in Fig. 326. The lift then starts into operation, forcing water up into the tank until the water reaches the level B. When this level is reached the float X is raised, thus opening the upper inlet into A, filling the latter with water, and raising the float F, which shuts off the ball cock.

The pressure of the water in the pipe between the lift and the tank is sufficient when the ball cock closes to close the automatic cut-off, which results in cutting off the water pressure from the lift. The water lift remains inactive until enough water has been drawn from the tank to bring the water level down to C again. By the use of the valves A and B, water from the city mains may be delivered to the fixtures when the regular supply is for any reason cut off. A modification of this system is often found in high city buildings in which the public water supply is not of sufficiently high pressure to supply the upper floors. In this system the lower floors are supplied by city pressure in the ordinary manner, while the upper floors are supplied from the automatic storage tank in connection with the water lift. It will be seen that under these conditions, the city pressure being the operating power and also the supply that is to be pumped, the supply to the lift and the suction must each be connected to the public water supply system. There are several other systems of supply, to which the water lift may be applied, which might be illustrated and described, if space permitted.

The advantages of the water lift are many, among them being the fact that its operation is automatic, requiring no attendant and little attention; it uses comparatively little water in operating; the action of the lift is comparatively noiseless, and there is little wear and tear on the working parts.

CHAPTER XXVIII

MULTIPLE CONNECTIONS FOR HOT-WATER BOILERS—RADIATORS AND COILS HEATED BY RANGE BOILERS

While the large majority of range connections are very simple, involving no novel features, very often conditions and requirements arise which alter the matter entirely, often producing very difficult problems. Among the problems constantly arising, are those which require the connection to the same boiler of two or more ranges, coils, or heaters, and the supply from the hot-water system of heat for radiators and coils. When these multiple connections are used on the kitchen range, the conditions are generally such that the range alone furnishes sufficient heating capacity for the boiler, the additional heating capacity being needed only during the colder months.

These facts necessitate the making of connections in such a way that the boiler may be heated properly by the several heating surfaces together, or by either of them alone. A combination such as mentioned above which is often demanded, is to be seen in Fig. 327, in which a coil radiator on the floor above the range boiler is required to be heated, this additional service making it necessary to connect a coil in the furnace to give additional heat when the heating coil is being used. The best method under the circumstances, is to carry the flow pipe from the furnace coil directly to the top of the heating coil. This method delivers the water to the radiator before it has cooled to any extent, and gives the heating coil more power than other methods of connection would. A vent on the coil is necessary to prevent it from becoming air bound.

The return from the coil is carried into the return from the range boiler to the range, and a connection made from this pipe into the return of the furnace coil.

There is nothing about the connection described to interfere in any way with the regular work of the boiler in supplying hot water to the fixtures of the house.

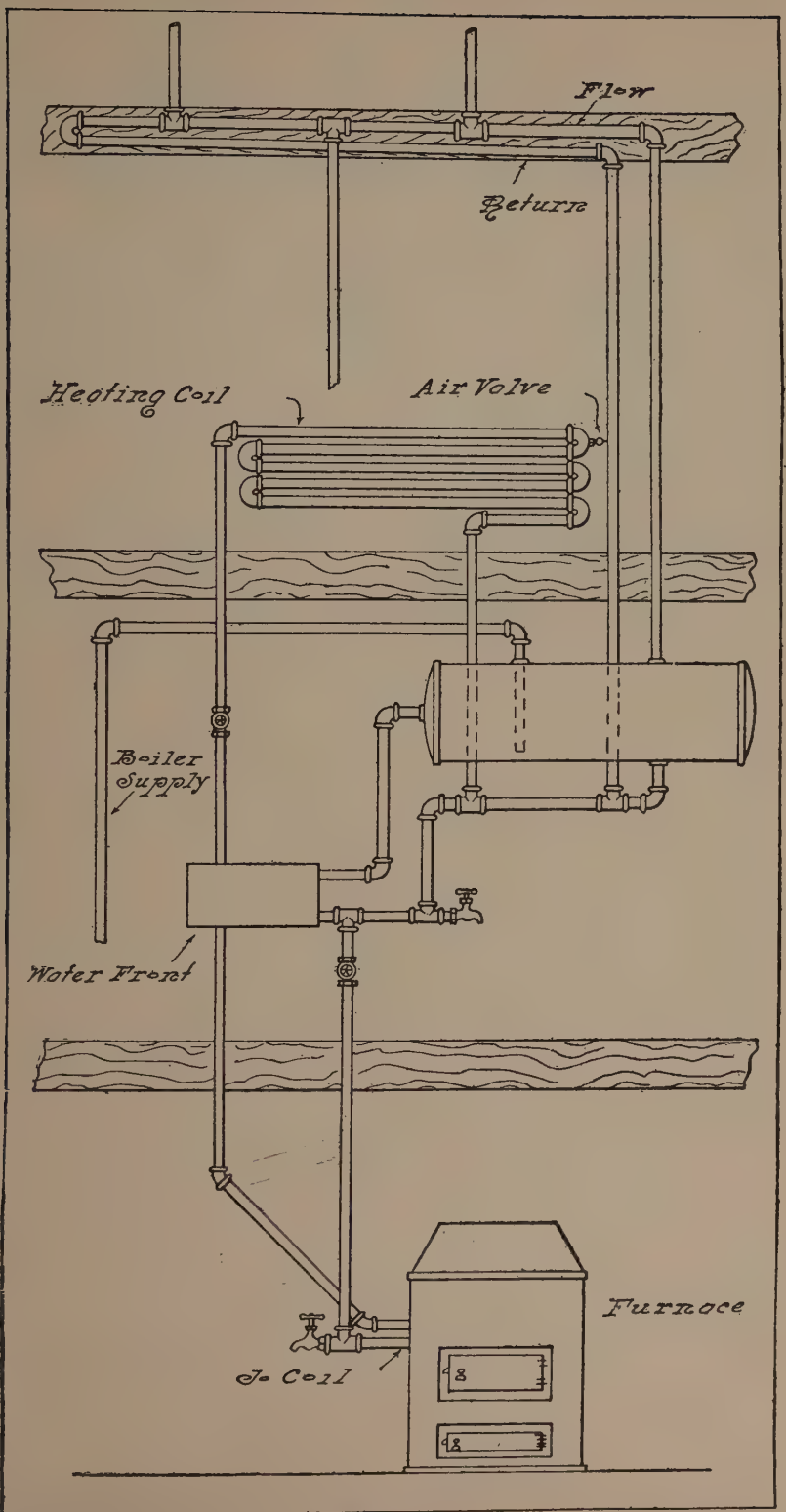


FIG. 327.—Horizontal Boiler Heated by Furnace Coil and Coal Range—

Valves on the flow and return of the furnace coil will enable the cutting out of the coil from the rest of the system when the furnace is no longer in use.

Another common requirement is the heating of a radiator by the hot-water supply, when the only heating surface is that of the

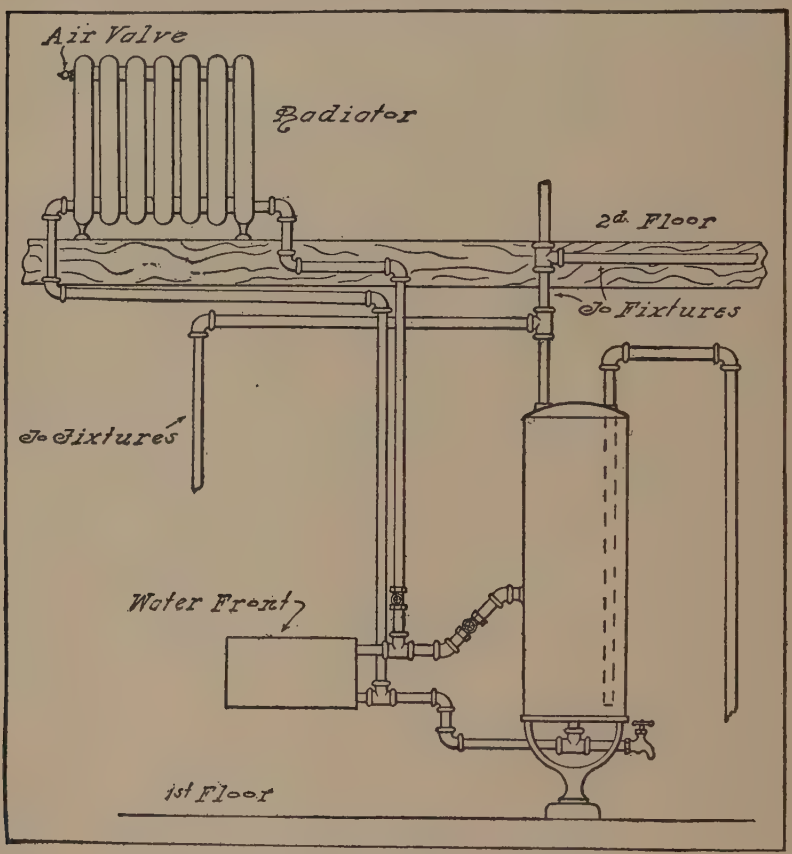


Fig. 328.—Radiator Heated from Range Boiler.

range. The great objection to this is that too much is often expected of such a connection, and also that it becomes a detriment sometimes to the regular work of the boiler. A small boiler heated by a small range should not be expected to provide both a hot-water supply and radiation.

A connection of this nature is to be seen in Fig. 328. A feed

pipe for the radiator is taken from the range connection and carried to the radiator, which should be provided with an air valve, the return being taken into the return of the range connection. Valves are placed on the flow pipes to boiler and to radiator, the latter being located at the radiator if more desirable. The use of

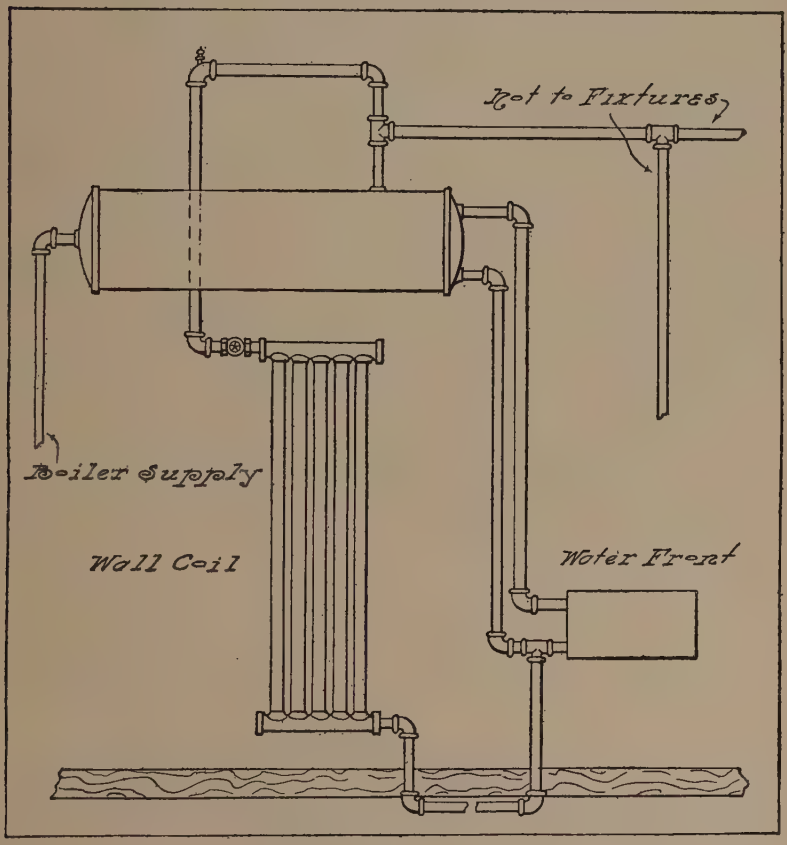


Fig. 329.—Wall Coil and Fixtures of Apartment Supplied by Horizontal Boiler.

these valves allows the heat of the range to be thrown either to the boiler or to the radiator, as the case may be.

For instance, if the demand for hot water is heavy, the radiator may be turned off for the time being. It must be seen to, however, that each of the two valves is not closed at the same time. In this connection it may be stated that valves should be used to as small

an extent as possible on hot-water supply work, as their wrong use is sometimes attended with serious consequences.

Small rooms, such as bath rooms, small bedrooms, etc., which

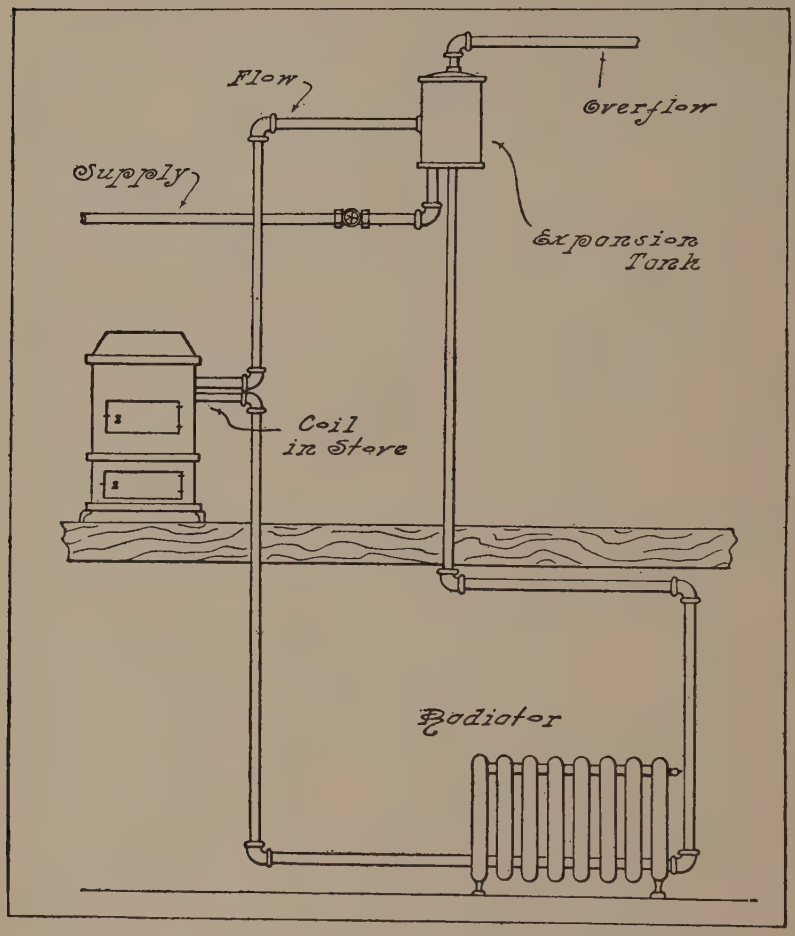


Fig. 330.—Heating Radiator by Stove Coil on Floor Below Stove.

would require only a few feet of radiation may often be successfully heated in this way.

Another familiar problem is that requiring the heating of a radiator or coil on the same floor as the range and boiler. Such an arrangement is shown in Fig. 329. To heat the coil, the flow pipe from the boiler is carried up and then directly down into the

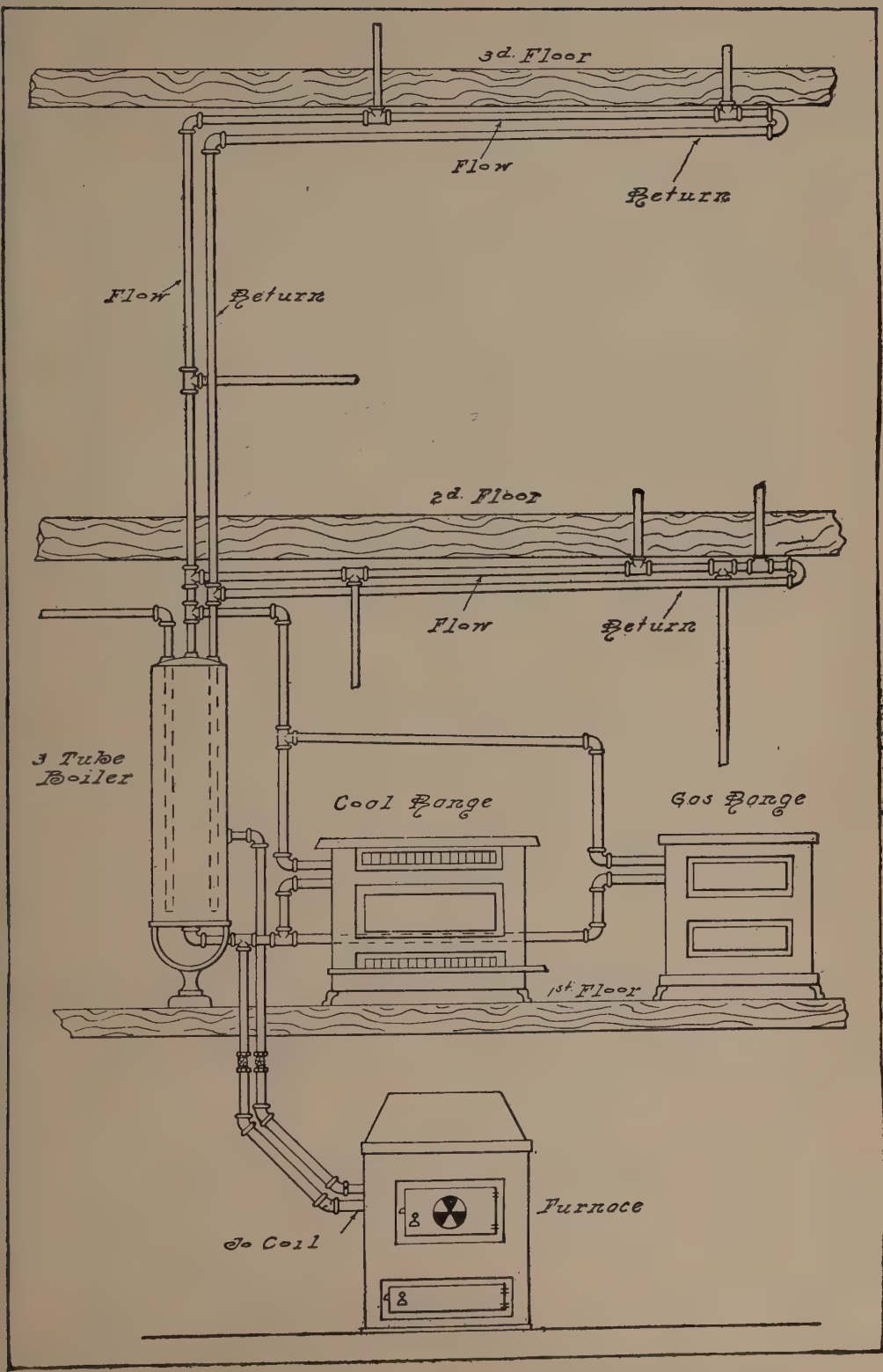


FIG. 331.—Range Boiler Heated by Furnace Coil, Gas Range and Coal Range.

top of the coil or radiator, a valve being placed on the pipe. The return is connected from the bottom of the coil or radiator into the return of the range connection. It is necessary to relieve this connection of air by means of an air valve at its high point. In the case of a supply system under tank pressure, the expansion pipe would perform this duty.

A more uncommon connection is shown in Fig. 330, in which a radiator is to be heated by a stove coil, without use of the hot-water supply system, and with the radiator on the floor below the stove. This radiator may be heated by running the flow pipe from the stove as high as possible, and connecting it into an expansion tank provided with an overflow. From the bottom of the expansion tank a feed pipe into the bottom of the radiator is taken, and the return end of the radiator connected back to the return of the coil. The water in the tank must stand above the opening of the flow pipe into it, and should be turned on from time to time to make up for any loss that may have been sustained.

The heating of a radiator under these adverse conditions is due to the weight of water rather than to circulation, and can be made to give fair results with a good heating surface in the stove.

The range boiler is very often fed from two or more different sources, such, for instance, as kitchen range, furnace coil, laundry heaters, gas ranges, etc. Such a combination is seen in Fig. 331 in which the boiler is heated by a coal range, gas range, and furnace coil. Either one of these sources of heat may be used independently of the others.

The connections of the flow pipes from the two ranges are so made as to produce quick heating of the boiler, while the flow pipe from the furnace coil enters the boiler at the side in the usual manner. The boiler shown in Fig. 331 is of the three-tube pattern, which allows the circulating pipe to be carried to the bottom of the boiler.

CHAPTER XXIX

THEORY FOR THE PLUMBER

In order to be successful in his work, the plumber of to-day must have at his command not only a knowledge of the practical requirements of his trade, but also a knowledge of the theory that underlies it. Every action that takes place in the drainage or supply system depends in some way upon some natural law, as also the action of various devices employed on the plumbing system.

It will be evident then that a knowledge of certain of these actions, and the laws governing them, is necessary to the plumber, in order that he may be able to understand and solve the various problems that are constantly arising in his work. Possibly to a greater extent than in almost any other trade the efficiency of the plumber consists largely in his ability to avoid trouble and to successfully get out of trouble that he already finds himself in.

Of the various phenomena to be considered, that of atmospheric pressure is perhaps of first importance. The atmosphere may be considered as a very light fluid, of certain depth, surrounding the earth. Although of small density, the weight of the atmosphere, which is computed to be about 45 miles in depth at the sea level, is very appreciable. Experiment has demonstrated that at sea level, the pressure of the atmosphere amounts to about 14.7 pounds per square inch. In ordinary computations, atmospheric pressure is considered as 15 pounds per square inch. Now in a square foot of surface, there are 144 square inches. Therefore, the pressure of the atmosphere on each square foot amounts to about 2160 pounds, or over a ton. This will serve to indicate what an immense pressure the atmosphere is capable of exerting.

That this pressure does not result in crushing everything that it comes in contact with, is due to the fact that the same pressure is exerted from all sides, thus equalizing the effect. Thus in the case of the human body, atmospheric pressure is exerted from with-

out and from within, the two forces balancing each other and producing no results. If, however, a vacuum is formed on one side of an object, and atmospheric pressure is exerted on the other side, the obvious result is the crushing in of the object.

The action of atmospheric pressure, combined with the formation of a vacuum or partial vacuum, is to be met in a variety of ways in the plumbing system, some of the more common instances being the following:

Whenever siphonage takes place, whether it is in connection with traps, or in connection with the range boiler, or the action of water-closets and various other fixtures, the action is due to the creation of a vacuum on one side, and the pressure of the atmosphere on the other. This also underlies the action of pumps. In the siphonage of a trap, a vacuum must necessarily have first been formed on the sewer side of the trap seal. When this condition has been fulfilled, there is nothing to oppose the atmospheric pressure exerted on the house side of the seal, and the result is that the contents of the trap is forced out by the pressure of the atmosphere. It will be understood, by the way, that a vacuum is a portion of space from which the air has been exhausted.

The siphonage of boilers occurs in the same way as the siphonage of traps. In the case of the boiler, however, the vacuum is generally formed by the passage out of the pipe supplying the boiler of the water held in it, while the vacuum on the drainage system is often produced by the passage past the entrance of the trap of a body of waste, through the pipe into which the trap connects. In the operation of the pump, the action is as follows: As the piston of the pump is raised, it causes the formation of a vacuum in the suction pipe, and the action of atmospheric pressure on the surface of the water in the well forces the water up through the suction pipe. If the vacuum were perfect, and there was not the friction of the pipe to be considered, the water would rise in the suction pipe nearly 34 feet above the level of the water in the well. A more or less imperfect vacuum and the friction of pipe and fittings results in cutting down this distance considerably, depending on the conditions that exist in each case.

The same principle underlies the action of the vacuum valve as well as other devices used on the plumbing system. Under

ordinary conditions, the vacuum valve remains closed, owing to the pressure of the water against the valve. When a vacuum occurs on the inner side of the valve, however, atmospheric pressure opens the valve, admitting air, and thus preventing the siphonage of the boiler. Various other examples might be mentioned, if necessary, of the effect of a vacuum and atmospheric pressure in connection with the plumbing system.

Atmospheric pressure is exerted not only downward, but in all directions. Hydrostatics is another subject which holds much interest for the plumber. Hydrostatics treats of the conditions of liquids in equilibrium, and of the pressures which they exert. One of the principles demonstrated in the study of this subject is that liquids are almost incompressible. This principle is made use of in the hydraulic ram. On the other hand, air is extremely compressible. The air chamber is often used on pumping and supply systems, the compressibility of air allowing the air chamber to take up any shock which may occur on the piping. When the air has become exhausted from the air chamber, however, and it has become filled with water, the latter being incompressible, the results of shocks through the pipes again become noticeable.

Another very important principle is the following: Pressure exerted anywhere upon a mass of liquid is transmitted undiminished in all directions, and acts with the same force on all equal surfaces, and in a direction at right angles to those surfaces. This principle may be demonstrated by means of the vessel shown in section in Fig. 332. In this vessel, the several openings are fitted with pistons of equal area. If pressure is exerted on the surface of the water in the vessel by means of a piston working through another opening, the six pistons shown will be pressed out in the direction of the arrows, a distance equal to that through which the additional piston is forced in. In any body of water, the pressure at any level is proportional to the depth, and the pressure is the same at all points on that level. The pressure of a column of water one square inch in area, and one foot high, is equivalent to .434 lbs. Therefore, to find the pressure of a column of water, multiply its head in feet, by .434. The pressure which the upper layers of a liquid exert on the lower layers, causes the latter to exert an equal reaction in an upward direction. This it will be seen, is a neces-

sary consequence of the principle of transmission of pressure in all directions. This upward pressure is called the buoyancy of the liquid. The pressure exerted by a liquid, due to its weight, on any portion of the liquid, or on the sides of the vessel in which it is contained, depends on the depth and density of the liquid, but depends in no way upon the shape of the vessel or upon the quantity of the liquid. Another principle, which is well understood, is the fact that water will always strive to reach its own level. The

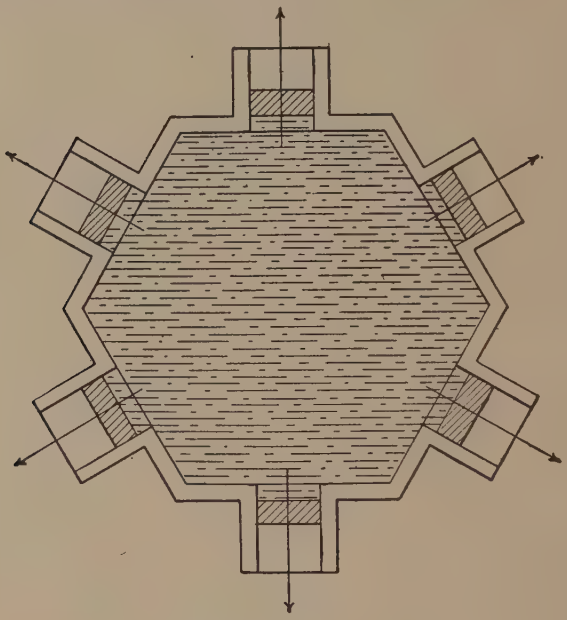


FIG. 332.—Direction of Pressure.

fact, however, that this principle underlies the action of the artesian well is probably not so well understood.

In Fig. 333 is shown an illustration from which the principle governing the artesian well, may be studied. Wherever this well is to be found, it will also be found that the strata composing the earth's surface is of two kinds, the one permeable to water, such as sand, gravel, etc., the other impermeable to water, such as clay. Let it be supposed, as shown in Fig. 333, that in a natural basin of greater or less extent, there are two impermeable layers, A B and C D, inclosing between them a permeable layer, E F. The

rain water falling on the part of this permeable layer which comes to the surface, will filter down through it, and following the natural fall of the ground will collect in the hollow of the basin, from which it cannot escape, owing to the impermeable nature of the layers above and below it. The result is, that the space between the impermeable layers fills with water throughout its course.

If now a hole is bored from the surface, through the upper impermeable layer and into the water-bearing stratum, the water escaping, will endeavor to reach the level from which it has descended, the result being that it will gush out to a height depend-

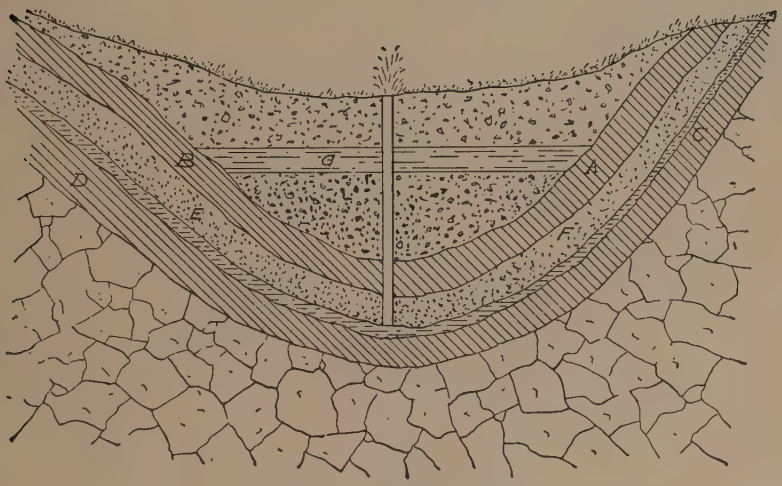


FIG. 333.—The Artesian Well.

ing on the difference between the levels at which the boring is made and the point at which this stratum comes to the surface. The water which feeds an artesian well often comes from a distance of sixty or seventy miles, and these wells are sometimes capable of delivering several hundreds of gallons of water per minute. In the action of the artesian well, it is not atmospheric pressure that forces the water up, but the pressure of the column of water between the well and the point where the water-bearing stratum comes to the surface.

Capillarity is a characteristic of liquids, which as seen in a preceding chapter, is often met with in connection with traps. While the phenomena of capillary action are numerous, there is

only one feature of the subject which will directly interest the plumber. This feature is the fact that when a body in which very minute tubes or pores exist is immersed in water, the liquid will rise through these minute tubes to heights much above the level of the water itself. In order that this may happen, the substance immersed must be capable of being moistened by the water. The action is not due to any pressure or to action of the atmosphere, but to a sort of attractive force between the substance immersed and the liquid. If, for instance, a fine glass tube is thus immersed, the liquid will be seen to rise in it to a considerable height above

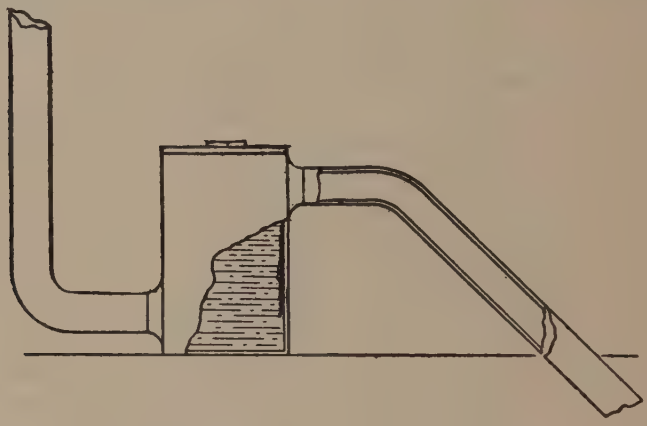


Fig. 334.—Destruction of Trap Seal by Capillary Action.

the level of the water. The application of this principle to plumbing, appears in the destruction of trap seals by capillary action.

In Fig. 334 is shown a trap into which a collection of lint, etc., dips. This material reaching from the trap seal into the outlet presents a danger to the trap seal much greater than would at first appear. By capillary action, the water in the trap is drawn up through this collection of lint, threads, etc., and deposited in the outlet a drop at a time. In the course of a comparatively short time the entire seal of the trap may be drawn out in this manner.

The friction of liquids is a matter which applies directly to supply work. In flowing over a surface, against the surface of a pipe, for instance, a liquid meets with more or less resistance,

and in addition, there is a certain amount of friction between the molecules or particles of the water itself. This is called fluid friction. Fluid friction does not depend in any way upon the pressure of the liquid against the surface with which it comes in contact. It increases with the roughness of the surface and with the area of the surface, and within certain limits it increases with the velocity of the liquid.

Friction has greater effect in the case of small pipes than in large pipes. The reason for this is that in small pipes a larger proportion of the liquid comes in contact with the surface of the pipe than in large sizes. In long lines of pipe the friction may be of such an amount as to entirely cut off the flow of water.

Bends and other fittings add greatly to the friction in pipes. It is for this reason that changes in direction of pipes are often made by bending the pipe rather than by using bends or elbows.

The effects of heat present a subject which is also of very great interest to the plumber. The theory of heat now generally accepted, is that it is a form of motion. According to this theory, all bodies are made up of infinitely small particles or molecules, which are in constant motion. When heat is applied these vibrations increase, and expansion of the body results. If heat is continued, the expansion at last becomes so great that the particles will not hold together, the body loses its form and passes into the liquid state. If now heat is still further applied, by virtue of the continued expansion of its particles, the liquid mass will become transformed into a gas or vapor. When heat is withdrawn, the reverse action of contraction takes place.

Expansion and contraction of different metals varies considerably. In the calking of lead joints on cast-iron pipe this is to be seen. A metal or composition of metals has long been sought which in cooling will not contract so much as lead will, for as any workman well knows, when it cools, calking lead will draw away from both surfaces with which it is in contact. Type metal is about the only composition which answers this requirement, as its expansion and contraction are very slight. This metal, however, is not only too expensive for this purpose, but is too hard for calking.

It is because of the expansion of water when heated that

larger sizes must be used on flow pipes than on returns, and it is for the same reason that expansion tanks must be used.

It is due to the expansion and contraction of bodies that circulation takes place, whether it be circulation of water, steam, or air. As water becomes heated, the heated particles are in a more expanded state than the colder particles, and therefore are lighter. They therefore tend to rise, allowing the colder and heavier particles to fall and fill their places. The heating of air results in similar action.

Water is a substance which expands and contracts differently than any other substance. Other substances expand when heated and contract when cooled. At a certain definite temperature, however, water will expand whether heated or cooled. This temperature is 39.2° F., the temperature at which water is the heaviest. If this were not so, in freezing, water in the form of ice would be heavier than the water itself, and ice would be formed at the bottom of a body of water rather than at its surface.

Because of its ability to expand when heated to a high point, or cooled to a low point, water will burst the vessel in which it is contained under either condition; in the former case by freezing, and in the latter by the expansive force of steam. In freezing, the expansive force of water is very great, about 30,000 pounds to the square inch.

The boiling of liquids is a subject of interest. Boiling is the rapid production of elastic bubbles of vapor in the mass of a liquid. When water is heated at the lower part of a vessel the first bubbles are due to the disengagement of air which the water has absorbed. Small bubbles of vapor then begin to rise from the heated parts of the sides, but as they pass through the upper layers, the temperature of which is lower, they condense before reaching the surface. The formation and condensation of these first bubbles result in the singing noticed in water before it begins to boil. Finally, large bubbles rise and burst at the surface, and it is this action that constitutes boiling.

The temperature at which water will boil, that is, its boiling point, rises with the pressure. Therefore, water will boil more quickly at the top of a mountain than at its base, as atmospheric pressure at the top is less than at the bottom.

For any given pressure, boiling begins at a certain temperature, which for equal pressure, is always the same for the same liquid.

Regardless of the amount of heat that is applied, as soon as boiling commences, the temperature of the liquid remains stationary. Thus, water boils at 212° F. at sea level, and no matter how heavy a heat is being applied, the temperature of the water after it begins to boil remains at 212° F. This is a point worthy of remembrance, as there is a general mistaken idea that the more heat is applied, even after water begins to boil, the higher the temperature of the water will be.

Water which contains matter in solution will not boil at as low a temperature as pure water. Thus, a water containing salt, or acid of any kind, will not boil at 212° F. Substances held mechanically by the water, however, such as sediment, sand, etc., do not affect the boiling point.

Evaporation is a subject in which the plumber has an interest, as evaporation is one of the most dangerous evils that the trap seal is subject to.

Evaporation is the slow passage of a liquid into the form of vapor. Whatever may be the temperature at which a vapor is formed, an absorption of heat always takes place. If, therefore, a liquid evaporates, and does not receive from other sources a quantity of heat equal to that which is given out in producing the vapor, its temperature sinks, and the cooling is greater in proportion as the evaporation is more rapid. Experiments have been made, showing that water may be frozen by means of rapid evaporation. Evaporation increases as the temperature increases, and as the exposed surface increases. Currents of air passing over the surface of a body of water also increase the rate of evaporation. The latter cause is the reason that the vent system increases the rate of evaporation of trap seals.

The vent system communicates with the outer air, and it is the currents of air passing through the piping that adds to this evil. The reverse action of evaporation is that of condensation. Condensation is the passage of a vapor into the liquid state. Warm vapors coming in contact with cold surfaces result in the condensation of the vapor. This action underlies the operation

of distilling apparatus, the vapor of the liquid that is boiled being condensed again into the form of liquid. Condensation of vapors in the vent system necessitates the running of vent pipes in such a way that the condensation may not accumulate in the pipes, but will drain off into the drainage system. In summer time, the condensation accumulating on cold-water pipes is an evil often encountered.

Heat may be transmitted in two different ways, by conduction and by radiation. When a piece of metal is heated at one point this heat gradually spreads through the metal. When heat is transmitted through the mass of a body, from one particle to another, the body is said to be heated by conduction. Metals are excellent conductors of heat.

Heating by radiation is of more practical importance to the plumber, however, than heating by conduction. When a person stands at a little distance from a fire or other source of heat, he experiences the sensation of warmth. The heat in this case is not transmitted by conduction by the intervening air, but the rays of heat pass through without raising the temperature of the air. This heat is transmitted by radiation. That the heat is not due to the temperature of the air may be known from the fact that if a screen be interposed the sensation at once disappears, which would not be the case if the surrounding air had a high temperature. Therefore, it is seen that bodies may send out rays which excite heat, and which pass through the air without heating it.

Fusion is a subject connected with that of heat, which has been already slightly touched upon. Fusion is the passage of a solid into the liquid state. Most substances have the power of fusion. Exceptions are to be noted, however, in such substances as wood, paper, coal, etc., which instead of fusing, decompose under high temperatures. Many substances have long been considered impossible to fuse, but as it has become possible to produce higher temperatures, their number has steadily decreased. Such hard substances as rock crystal have been fused. Every fusible substance begins to fuse at a certain temperature, which is invariable for each substance if the pressure be the same. Regardless of the intensity of the heat applied, from the instant that

fusion begins the temperature of the body ceases to rise, and remains constant until the fusion is complete.

Solidification is the reverse of fusion, it being the passage of a body from the liquid to the solid state. Every body, under the same pressure, solidifies at a fixed temperature, which is the same as that of fusion of the same substance. From the commencement to the end of solidification, the temperature of the substance remains the same.

In connection with this chapter, the subject of gravity, though not of the direct, practical importance to the reader that other subjects considered may be, should not be overlooked.

Briefly stated, gravity is the tendency of any body to fall toward the earth. When a gravity supply of water is spoken of, what is meant is that the supply is due not to any outside force, but simply to its tendency to fall. The same significance is attached to the gravity heating system. Weight is the common meaning of the term gravity. Thus, in the gravity supply system, water is delivered by gravity, that is, by virtue of its weight. In drainage work, the common system is known as the gravity system as distinguished from systems in which the drainage is forced along by special ejectors or pumps.

A few remarks concerning the properties of water will not be out of place. Water is composed of hydrogen and oxygen, two parts of the former to one of the latter. Water readily absorbs gases, this action occurring to the greatest extent when the pressure of the gas upon the water is greatest, and at low temperatures. The reason for this is that when under pressure and at low temperatures, the elastic force of the gas is less than under the reverse conditions. The absorption of gases by water renders it necessary to cover storage tanks for water when located in such positions as to be liable to such danger.

Water is hard or soft according to the relative amount of certain salts which are present in it. These salts are generally taken up by the water from the earth, the most common being those in which lime is present. A water containing these salts is said to be hard. Rain water, being free from salts of this nature, is soft, and in addition is the purest water obtainable. Rain water or any other pure water, however, often attacks certain metals more

strongly than other more impure waters. This is due to the fact that the elements of which it is composed are more free to unite with other substances than water which already contains more or less matter of a chemical nature.

Air is composed of oxygen, nitrogen, and a small amount of carbonic-acid gas. The proportions are about one part of oxygen to four parts of nitrogen. Nitrogen is a poisonous element, very destructive to life. Upon the presence of oxygen all combustion and chemical action depends. While nitrogen is destructive of life, oxygen gives life, although the former is necessary to dilute the latter, for otherwise the process of oxidation would be so severe that life could not be maintained.

Other subjects might be taken up to advantage if space allowed, but for lack of that, the author has devoted himself entirely to those subjects which have a more or less practical application in the work of plumbing. Much other material, such as the subject of siphonage, will be found at different points, but which for various reasons are considered under other headings.

CHAPTER XXX

DRAWING FOR THE PLUMBER

It is not the purpose of this chapter to go extensively into the subject, but to give some of the necessary principles which will be of assistance along these lines. While it is not to be expected that the average workman in the plumbing trade is or can become a skilled draughtsman, the requirements of the times certainly demand that the plumber, if he is to make the most of his capabilities, must have a certain practical knowledge of the subject of drawing, as applied to his own trade. It is of inestimable value to the employing plumber and to the foreman on plumbing work, to be able to show intelligibly by means of a pencil sketch, for the benefit of workmen or customers, methods of connections, etc. Furthermore, in many cities of the country, boards of health now demand sketches of contemplated work, both on new and old construction, to be submitted before issuing a permit to perform the work. Again, in many cities, in order to secure a plumber's license, the applicant must be able to draw the connections for work as indicated by his examiners, and to be able to criticise intelligently drawings of plumbing construction of faulty nature. Journeymen plumbers' unions in many instances also require applicants for admission to pass an examination which includes the making and criticizing of plumbing drawings. These remarks will serve to show some of the reasons why ability to read and make drawings is a necessary part of the plumber's knowledge, and it may be truly stated that the necessity for such knowledge is steadily increasing.

The mechanical, architectural, and engineering draughtsman is compelled to go deeply into the subject, but the rudiments are sufficient as a foundation for the plumber, his greatest difficulty being in executing drawings neatly and in such a manner as to be readily understood.

The plumber really needs to be acquainted with only two views, these being known as the plan view and the elevation.

Experience shows that if he learns to properly distinguish between these two views, the plumber's greatest difficulty as a draughtsman will disappear, and that if he does not thoroughly master this principle, his drawings will in all probability be a confusion of plan and elevation, which it will often be impossible for another person to understand. A perspective view of plumbing connections, which, by the way, is a very difficult drawing to make, should very rarely be used by the plumber, although there is a strong temptation to make use of it.

Every object, if it is to be shown completely by drawings, will require two views, a plan and an elevation, although in showing plumbing work, one view will often, and probably usually show the work with sufficient clearness.

A plan view is a view obtained by looking down upon the object as it stands in its natural position. Thus a cellar plan or floor plan of a house is obtained by viewing the cellar or floor from a point above it. An elevation, on the other hand, is a view obtained by standing away from the object, and looking horizontally at it. Every object such as a house, would have four elevations, front, rear, and two side elevations. For the plumber's use, however, not more than two elevations, front and side, are ever needed, and in a great many cases only one elevation is required by him. He must know what the elevation of the house is, in order to know the distance between floors, the total height, etc., in figuring the amount of piping in vertical lines of pipe. He needs the plan view equally as much, to show him the horizontal lines of piping.

It will be clear then that a full knowledge of the work can be obtained only by means of at least one elevation, and the several plan views of the cellar and floors, and in estimating work, these drawings are always necessary. On the other hand, very often an elevation or a plan, as the case may be, will be sufficient. For instance, in showing the principles of certain work by means of a drawing, very often an elevation will show all that is necessary.

The idea of plan and elevation may be seen by reference to Fig. 335.

The first is a perspective view of a piece of pipe, and the other two views are the plan and elevation of the same piece of pipe.

The perspective view gives as much information concerning the object as the plan and elevation combined, that is, it shows the length, shows that it is cylindrical, and also the inside and outside diameters. On the other hand, the elevation shows only length and width, and gives no idea as to whether the object is square or round. In connection with the elevation, the plan is necessary, in order to show that the object is cylindrical instead of square, and

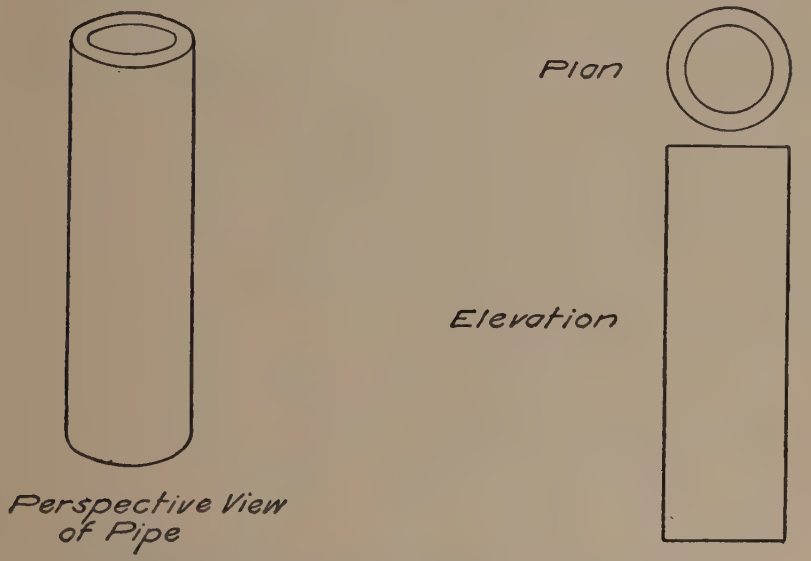


Fig. 335.—Perspective and Mechanical Views of an Object.

that it is a hollow cylinder and not solid. It may be asked, since the perspective in one view gives the entire information, while in the mechanical drawing two views are needed, why it is not better to use perspective views.

In the first place, it is very much more difficult and takes more time to make the perspective view of this piece of pipe than to make the two mechanical views. In the second place, in making a perspective view of a complicated system of piping and fixtures, the task would become so much more difficult than the making of the mechanical views, that the person not well versed

in such work could not expect to do otherwise than produce a drawing which would be utterly impossible to understand.

Regarding the plan and elevation, it may be stated that if the pipe of Fig. 335 had been a square pipe, the elevation would not have been different, but the plan would have been a hollow square, rather than the circular view shown.

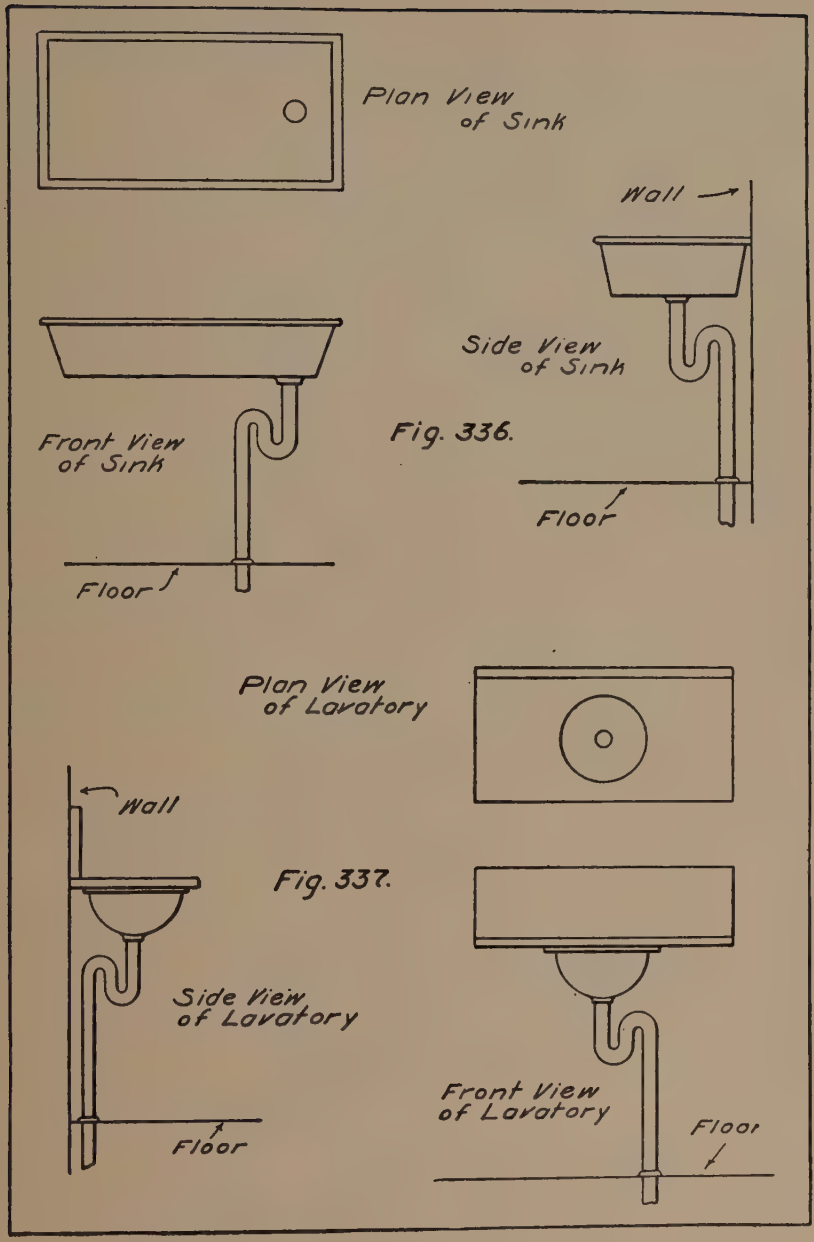
Another point that requires mention is the fact that if the pipe had laid upon its side instead of upon end, when the two views were made, the plan would then have been what the elevation now is, but shown lengthwise or horizontally, instead of vertically. The elevation in that case would be the same as the plan view now shows. If careful study is given to the foregoing simple principles, the subject of plan and elevation will be fairly well understood.

In looking over sketches drawn by workmen, it is especially noticeable that they invariably confuse plan and elevation in showing fixtures, such as sinks, lavatories, wash trays, water closets, etc. To give them a clearer idea of how these fixtures should be shown, Figs. 336 to 339 are given.

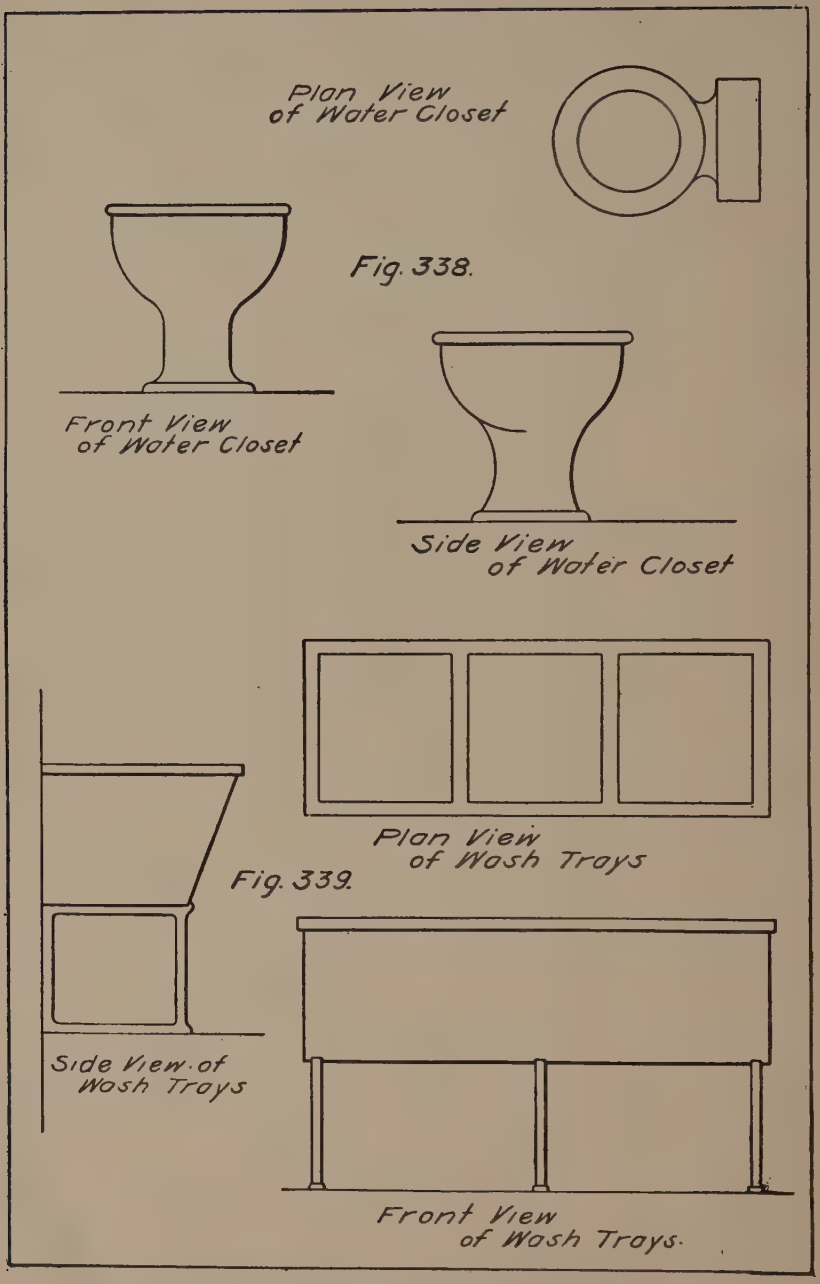
These several views are of common fixtures, and in most cases it is as well to show these simple forms of fixtures in drawings, as to show views of fixtures that are more complicated. For instance, the views shown of the lavatory would be much more easily made than those of many of the fancy, high grade lavatories, and they would show the principles involved fully as well.

One very important fact to be remembered, is that no one mechanical view can show all sides of an object, or give all the information that is to be obtained. It is one of the greatest faults of those who are not conversant with the subject, to endeavor to make a certain view show facts concerning an object which cannot possibly be shown by that view. The result of such attempts is usually a distorted drawing which can only be understood after much study and surmising as to the meaning of the one who made it.

The drawings which the plumber will generally require are made up largely of piping, and experience shows that the plumber in making such drawings will have better results if he will draw single lines for his pipe, instead of double lines, such as are shown



Figs. 336–337.—Plan and Elevations of Common Fixtures.



FIGS. 338–339.—Plan and Elevations of Common Fixtures.

on all illustrations in this work, with the exception of several in this chapter.

Fig. 340 will serve as an illustration of the advice to use single lines, and when compared with many other illustrations in this work of similar nature, it will be seen that the labor in making the single line drawing is very much less, and in general shows the desired principles with equal clearness. The plumber, in making drawings, especially if he is only fair in his execution, should cut out all unnecessary detail. It is often full as well to omit drawing fixtures, simply showing traps and connections, and by proper lettering showing the location of the several fixtures. This feature also appears in Fig. 340. The sizes of pipes may be indicated by figures as in the same illustration, although it is often well to indicate the main lines of pipe by heavier lines than those used for the rest of the work.

If the drawing is in pencil, and it is desired to distinguish between the venting and the drainage, it may be done by the use of red and blue pencils, one color for the venting, and the other for the drainage. Different colored inks may be used in the same way on drawings made in ink.

Another method is the use of broken lines for the vent work, and full lines for the drainage. These same methods are often used also in drawings showing systems of hot water supply and systems of steam and hot water heating, broken lines or blue lines showing returns, and full lines or red lines showing supply pipes. It is often very desirable, and sometimes necessary, in making drawings which are to show changes and additions to the plumbing system, to use these same methods in distinguishing between the old and the new work. This idea is brought out in Fig. 341, and is often used on drawings submitted to boards of health or plumbing boards.

Before leaving the subject of drawing, the matter of scale drawings should be considered. This branch of the subject is of great importance to the plumber, inasmuch as all architects' drawings are of this nature. The plumber must understand scale drawings, in order to be able to figure lengths of piping, etc., from architects' plans.

It is obviously impossible to provide drawings of such a

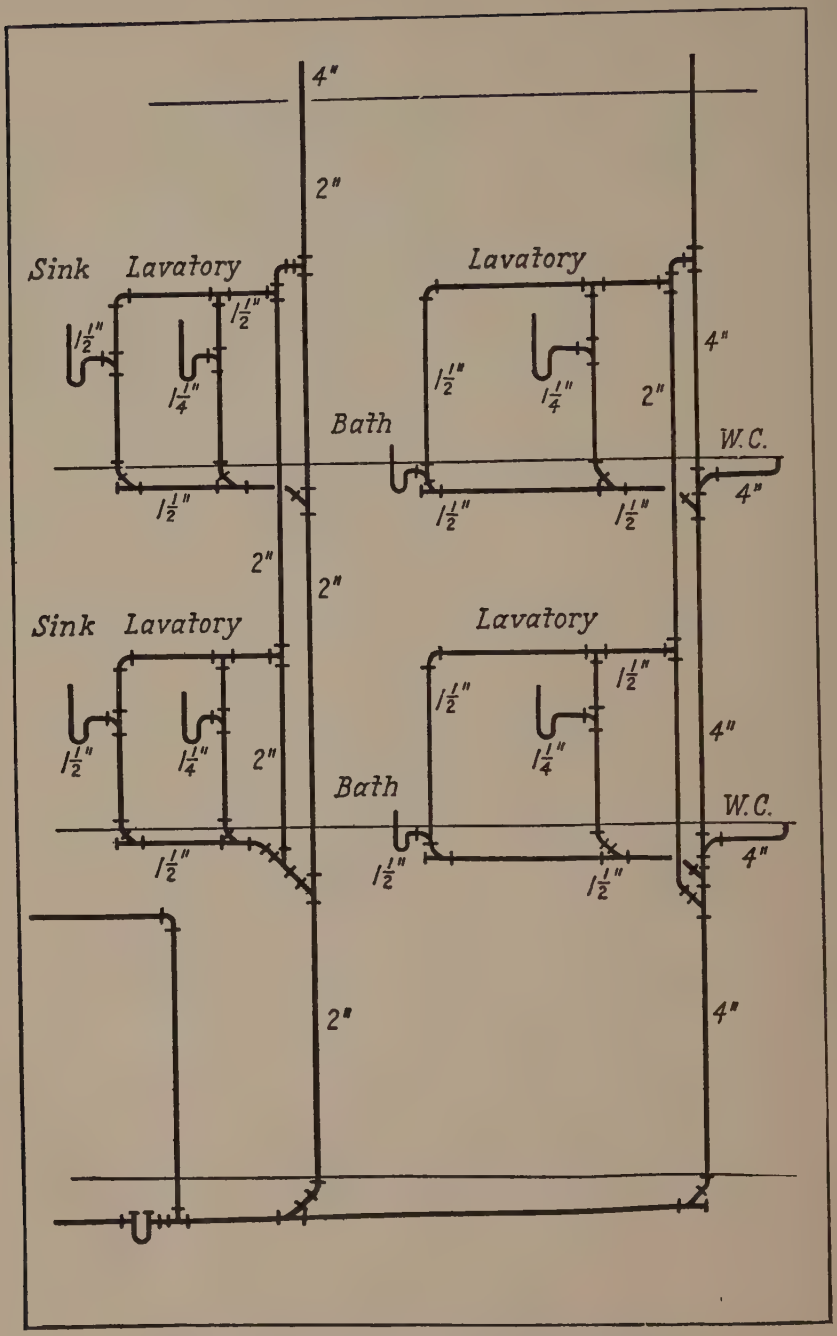


Fig. 340.—Single-Line Elevation of Plumbing System.

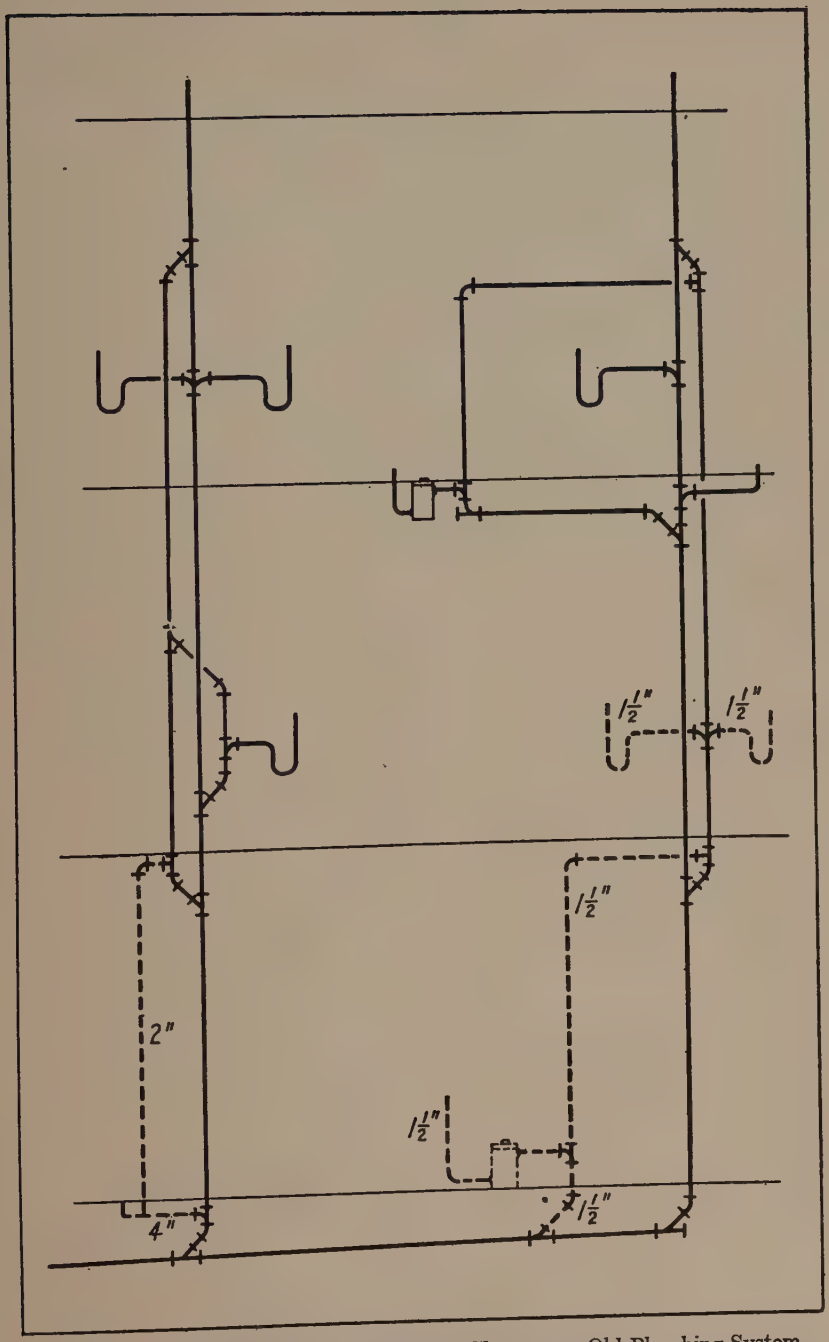


FIG. 341.—Single-Line Elevation Showing Changes on Old Plumbing System.

thing as a house, of full size. In order then to provide drawings of buildings, the architect reduces the size to such dimensions as will be desirable. Such reduced drawings are in the actual proportions of the building itself, but on a very much smaller scale. The most common architect's scale is $\frac{1}{4}$ inch to the foot, although on large building plans, $\frac{1}{8}$ inch to the foot is often used. The scale used is always named on each drawing of the set of plans. If the scale is $\frac{1}{4}$ inch to the foot, a quarter inch measured anywhere on the plan, means that the same measurement on the building itself would give one foot.

In Figs. 342 and 343 are shown two cellar plans of the same house and piping, the small one being just half the size of the large one. Supposing that the upper plan is drawn at $\frac{1}{8}$ inch to the foot, and the lower one at $\frac{1}{4}$ inch to the foot, an eight inch measured on the upper represents one foot, and a quarter inch measured on the lower represents one foot also. In referring to building plans in figuring work, care should always be taken before entering on the work, to ascertain the scale of the drawing. The writer can recall instances that have come to his knowledge, of plumbers figuring stock from plans drawn at one-eighth scale, as if they were drawn at a quarter scale, the result being that only one-half the straight pipe actually necessary for the work was figured on.

The only special knowledge necessary to the plumber concerning scale drawings is the use of the scale, which is a very simple matter. It simply means that in figuring lengths of pipe, whether vertical or horizontal, from the plans and elevation, as many feet should be allowed for the pipe as the distances measure in quarter or eighth inches, according to the scale of the drawings. Thus, on a cellar plan drawn at $\frac{1}{4}$ inch to the foot, a line of pipe measuring $5\frac{1}{4}$ inches would represent a length of pipe of 21 feet.

In Figs. 344 to 347 are shown the cellar and floor plans and elevation of a two story house. The elevation will show the vertical heights by the measurements of a, b, c, d and e.

A very important matter in many cases, is the offsetting of vertical lines of pipe, shown by the location of risers on the cellar and floor plans. If the estimator is careless in his work, he is liable to estimate vertical lines of pipe without giving attention to

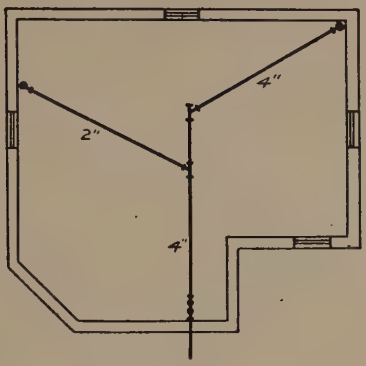


Fig. 342.

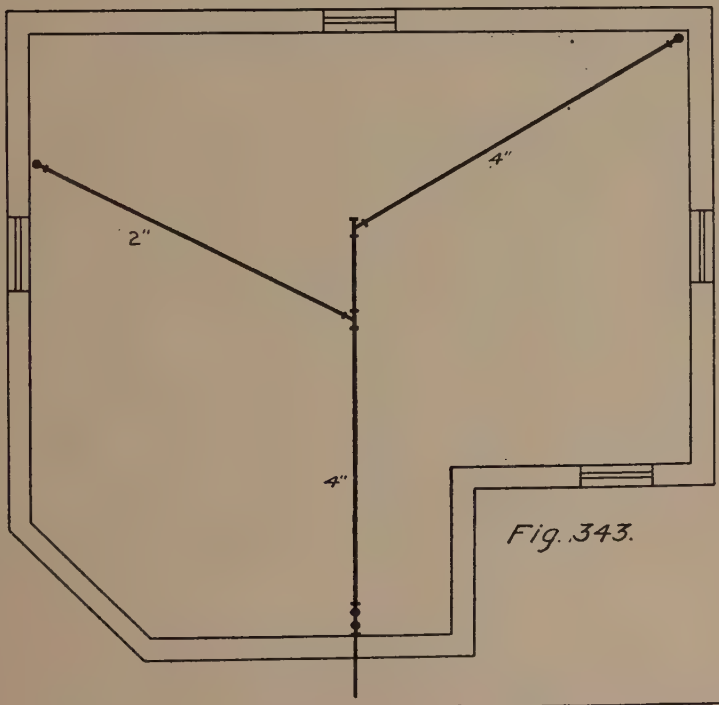
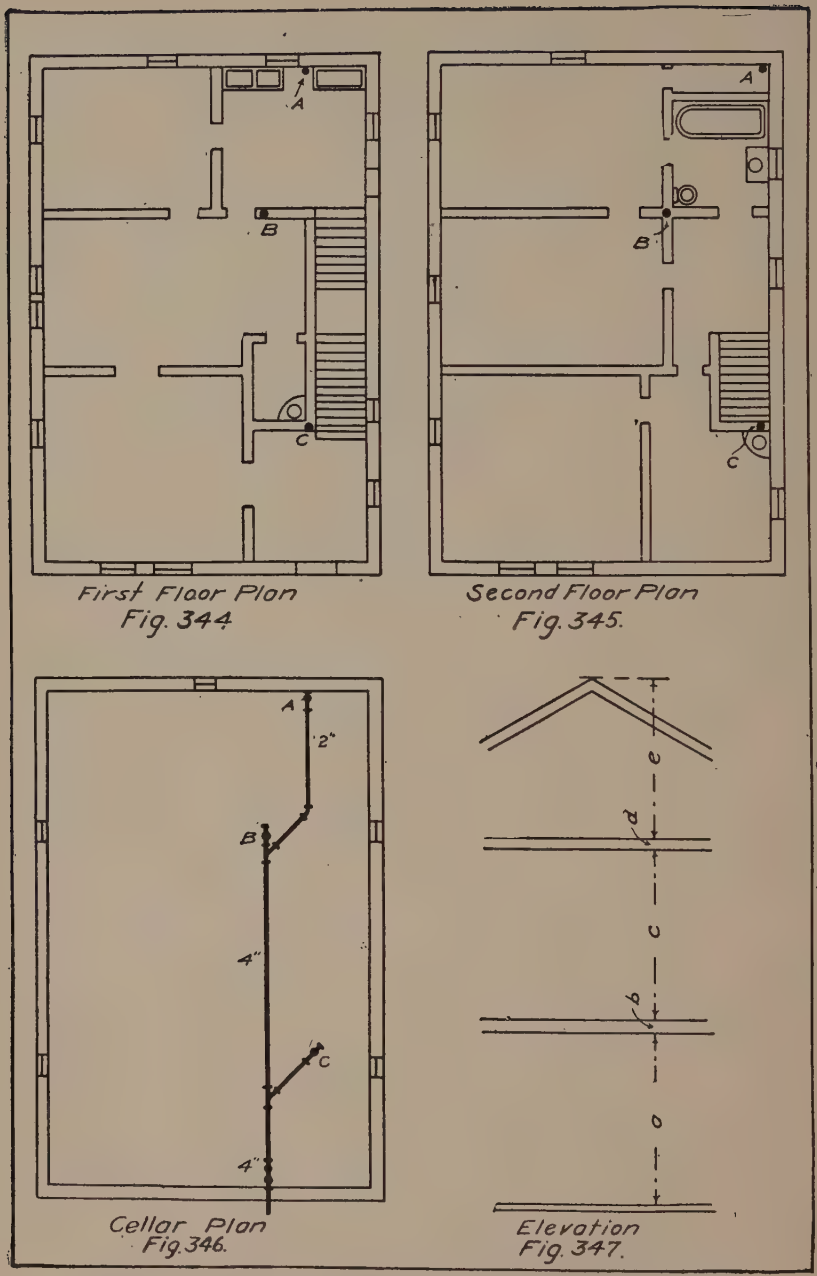


Fig. 343.

FIGS. 342–343.—Scale Drawing.



FIGS. 344–347.—Cellar and Floor Plans and Elevation of House.

offsets. This will cause him to leave out fittings from his estimate, and pipe also, in the case of long offsets.

Referring to Figs. 344-347, it will be seen from the location of stack A in the cellar and first floor plans, that it has no offset at these points, but has a straight rise. Its location on the second floor plan, however, shows that it does offset at the second floor, necessitating the estimating of two elbows, and a certain length of straight pipe.

The location of stack B in the three plans shows that this line of pipe rises through the roof without offsetting at any point.

In the case of stack C, the three locations of the riser show no offset at the first floor, but there is one at the second floor.

While the foregoing is by no means a complete treatise on this subject, the writer believes that those points which have special application to the plumber's requirements, have been touched upon, and that a careful study of the facts and suggestions given, will be of much assistance to any plumber who desires to perfect himself along these lines.

CHAPTER XXXI

EXAMINATIONS FOR PLUMBERS AND FITTERS

For many years a large majority of the cities and larger towns of the United States have required the plumbing trade to be conducted according to certain regulations or ordinances more or less strict, and in recent years this tendency has increased until at the present time, even in the more backward states there are few sizable communities that are not safeguarded by some kind of plumbing law.

In recent years moreover, many of the states have enacted plumbing laws, and have compelled all cities and towns of certain size to work under definite plumbing laws.

At different times there has been more or less agitation for a national plumbing code, but nothing has ever come out of this agitation, and it seems to be a question whether such a code could ever be made to work satisfactorily.

Needless to say, there has been a very wide range in the quality of both municipal and state plumbing laws. Some of these laws have been good and some bad; some have been just, and others have been unjust. However, it is not to be doubted for a single moment, that plumbing laws have in general been of very great benefit to the entire country. They have prevented a vast amount of careless work and work that might well be classed as criminal. In place of filthy, unsanitary conditions, most communities are now favored with plumbing that is free from objectionable features, and this condition is largely due to the law that has been enacted to govern plumbing construction.

Naturally, if plumbing is to be installed properly, the men that do the work must be qualified, must know the law, and be able to execute their work according to the law. This fact has made it necessary to incorporate in municipal and state laws, the requirement that all men engaged in the actual installation of plumbing construction, shall pass an examination in both the prac-

tical or manual work connected with their trade, and also in the theory underlying it. In some instances both the employing plumber and the workman are required to stand examination, and in other cases, one or the other of the two classes, but not both, must take the examination.

Plumbers' local unions have not been slow to apply the advantages of examinations to their own organizations, and today many of these locals require candidates for membership to pass a rigid examination before being admitted to membership.

Certainly the requirement of the state, of the city or town, and of the union, that applicants shall first show their right to work at the trade, by passing a creditable examination, must have had a very great influence for good.

There have been many instances where examinations have been given that were unjust, but this does not alter the main fact that the requirement of examination has proved of great benefit both to the community at large, and to the plumbing trade itself.

These examinations can readily be made so severe that the examiners themselves could not gain a passing mark, but such a course is to be condemned. The examination is given simply to prove a man's worth, and to do this it is not necessary or right to make it unduly severe.

The practical part of the plumber's examination takes care of itself, or in other words, it is in the plumber's own hands to fit himself to pass this part of his test, and it is not our present purpose to attempt to help him along this line.

In addition to the practical or manual work, most of these examinations include a set of questions which are to be answered. It is largely in these questions that injustice is done to the one who is being examined. We have known for instance, of the asking of such a question as this—what are the chemical symbols for lead, tin, antimony, and bismuth? It is not to be supposed that the education which the average plumber receives, would have given him the knowledge that would enable him to answer such a question as this, and if he were able to give the correct answer, we can hardly see wherein this particular knowledge would be of any practical value to him whatsoever.

However, the answering of the examination questions that are

invariably given in these tests, is a very important part of the examination. Preparation for this part of the examination should cover a long period, for it is not the ability simply to answer the questions, that should be sought, but the general knowledge of the subject of plumbing which would make the answering of them a certainty.

There are books well known to those connected with the plumbing trade, which are written very largely as a means of preparation for these examinations, and these books will be found of great value to the young man in preparing for this ordeal.

But besides the manual work, and the answering of questions covering the practice and theory of plumbing, there is a third part of the plumber's examination, which concerns the correction of drawings showing wrong plumbing connections, and it is with this part of the subject that this chapter is especially concerned.

For this part of the examination, the examining board is generally supplied with a number of incorrect drawings, this fact making it more difficult for one applicant to pass along to another, information concerning the contents of the drawings used.

In Fig. 348 we show an illustration giving a general idea of the character of one of these drawings, or examination charts as they are generally called. It will readily be seen that the errors that can be shown in such a drawing are endless, and that in order to locate the errors it is necessary for the applicant to possess a thorough knowledge of plumbing. It will also be noted that in some respects errors that would exist under one plumbing ordinance, might not stand as errors under some other ordinance.

For instance, if the city ordinance calls for a main trap, and the examination chart shows none, this would constitute an error. In another city, where the main trap is not allowed, the reverse would be true.

We know of no better method of preparing for an examination than by correcting such work as shown in our illustration and similar ones.

The manner in which this examination is conducted, varies. In some cases it is necessary only to point out the errors, and to explain orally to the examiners how the work should be performed. In other cases the applicant is expected to put in writing his

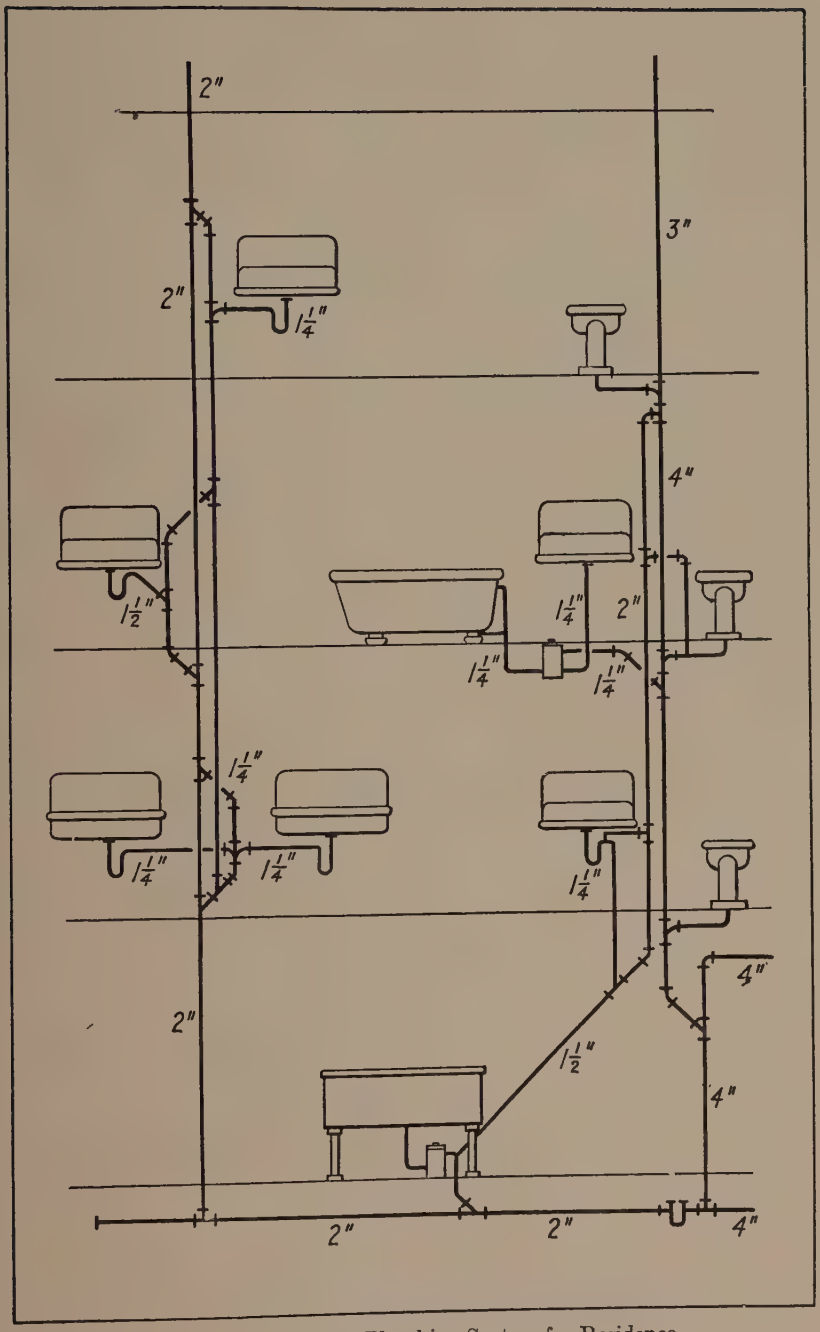


Fig. 348.—Incorrect Plumbing System for Residence.

criticisms and suggestions concerning the wrong work, and in still other instances, he is expected to re-draw the plumbing system and in his drawing to show the work correctly installed.

The latter requirement is for most men the most difficult, as in order to comply, a man must have some knowledge of the requirements of drawing. Therefore, it is an excellent idea for the young plumber to study the subject of drawing to as great an extent as possible for him. It will not only help him in his preparation for examination, but in every phase of his work as a plumber.

In Fig. 348, the examination chart there shown, covered only the drainage system, but often these charts cover also the hot and cold water supply system as well, and we show an examination chart of this description in Fig. 349.

If the plumbing fixtures on the chart are numbered, the work of the applicant will be made considerably easier than it would otherwise be, and we would therefore suggest that if they are not numbered, it would be well for the applicant to number each fixture at the very outset, before he attempts any corrections. Suppose for instance, there are two bath rooms shown on the second floor, and an error found in the connections of one of the lavatories, it would certainly be easier to state that a certain error existed in the connections of fixture No. 3 than to make the same statement concerning the lavatory in the right hand bath room on the third floor. The numbering of the fixtures is a small matter, but it will save the man that is being examined, considerable time and trouble in his written work.

The two incorrect plumbing systems already mentioned, are elevations, but some of the examination charts used show cellar plans, and such an incorrect plan we show in Fig. 350. It will readily be seen that on such a drawing as this, not so many or such a variety of errors can be made as in the case of an elevation.

Although this work is written for the plumber, whatever we have said in this chapter will apply also to the steam fitter, and for his benefit we are showing an incorrect heating system in Fig. 351.

This drawing shows the cellar plan of the piping for a two-pipe hot water heating system.

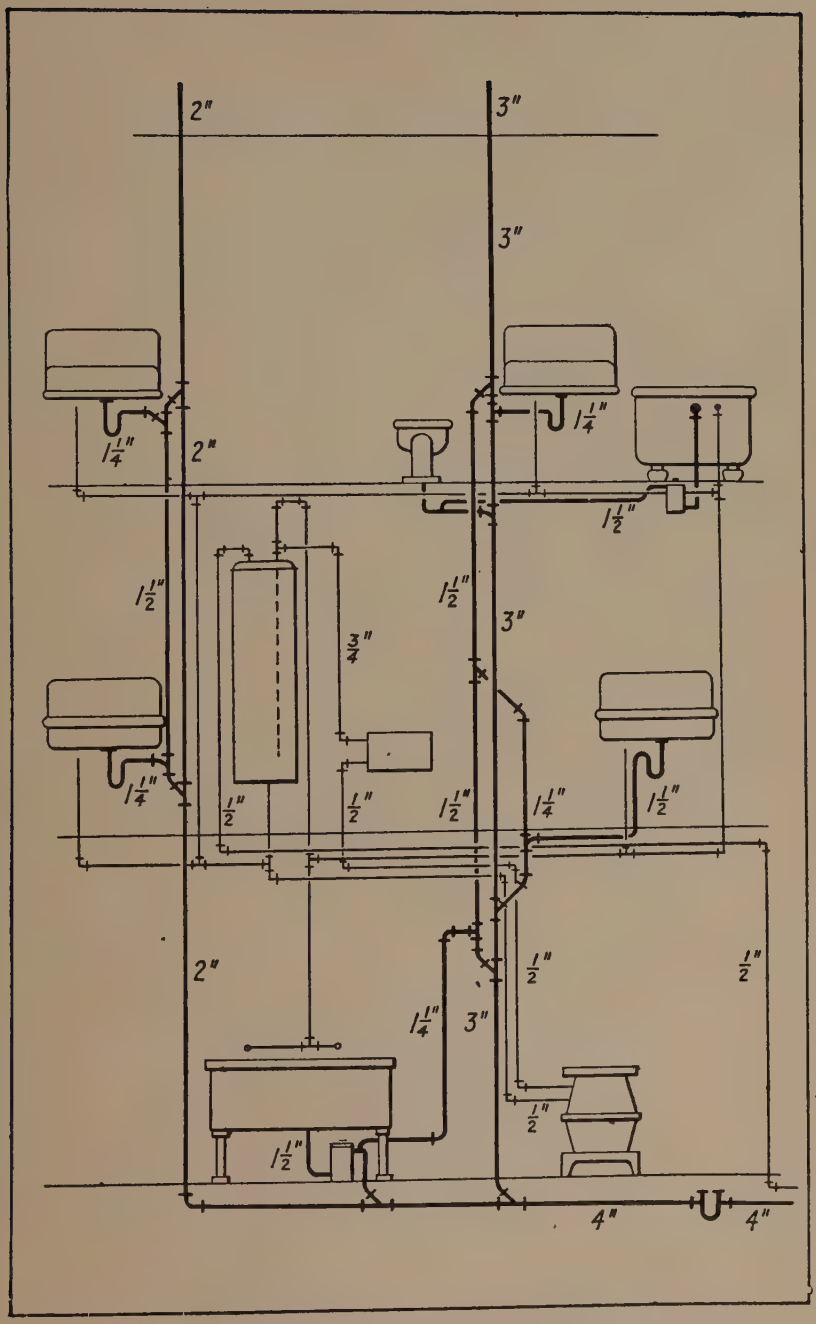


Fig. 349.—Incorrect Plumbing System for Cottage House.

Another incorrect drawing of a heating system is seen in Fig. 352, this being an elevation.

Another method of examination by the use of drawings is by means of such drawings as shown in Fig. 353. This shows the fixtures for a complete plumbing system, but without piping of any kind, and the applicant is expected to draw on this sheet the connections for a complete plumbing system for the fixtures shown, this generally to be done according to the local plumbing ordinance. It will be seen that there might be any number of different layouts, each applicant working it out according to his own ideas. Generally the instructions call for the naming of sizes of all pipes.

In the same way, Fig. 354 is used in the examination of steam and hot water fitters. In this instance, the examiners might instruct the applicant to show the piping for any one of the several different systems of heating.

The reader will readily see that he can do a great deal toward preparing himself for examination, by working out different layouts similar to those that we have shown.

Another kind of test for steam fitters is shown in Fig. 355. Here the floor plans for a house are given, with radiator locations shown, some of these locations and possibly all of them, being wrong. It is the duty of the man being examined, to show proper locations. It will be noted that the points of the compass are given, or otherwise it would not be possible to give right locations.

This sort of test can be extended in other ways. For instance, if sizes of rooms and windows are given, the applicant might be required to name the amount of radiation for each room.

Still another type of examination form may be seen in Fig. 356.

The sheet is divided into two sections. In the left hand section is shown a plumbing system having numerous defects, and in the right hand section fixtures only are shown, these being located as in the opposite section. The applicant is supposed to draw in all drainage and vent piping. This seems to be an especially fair sort of examination, as so much of the most difficult part of the work is already completed, and this is quite a help to the man who has had no drawing experience.

This same type of examination is also provided for steam fitters. One side of the sheet shows a defective system of piping, and on

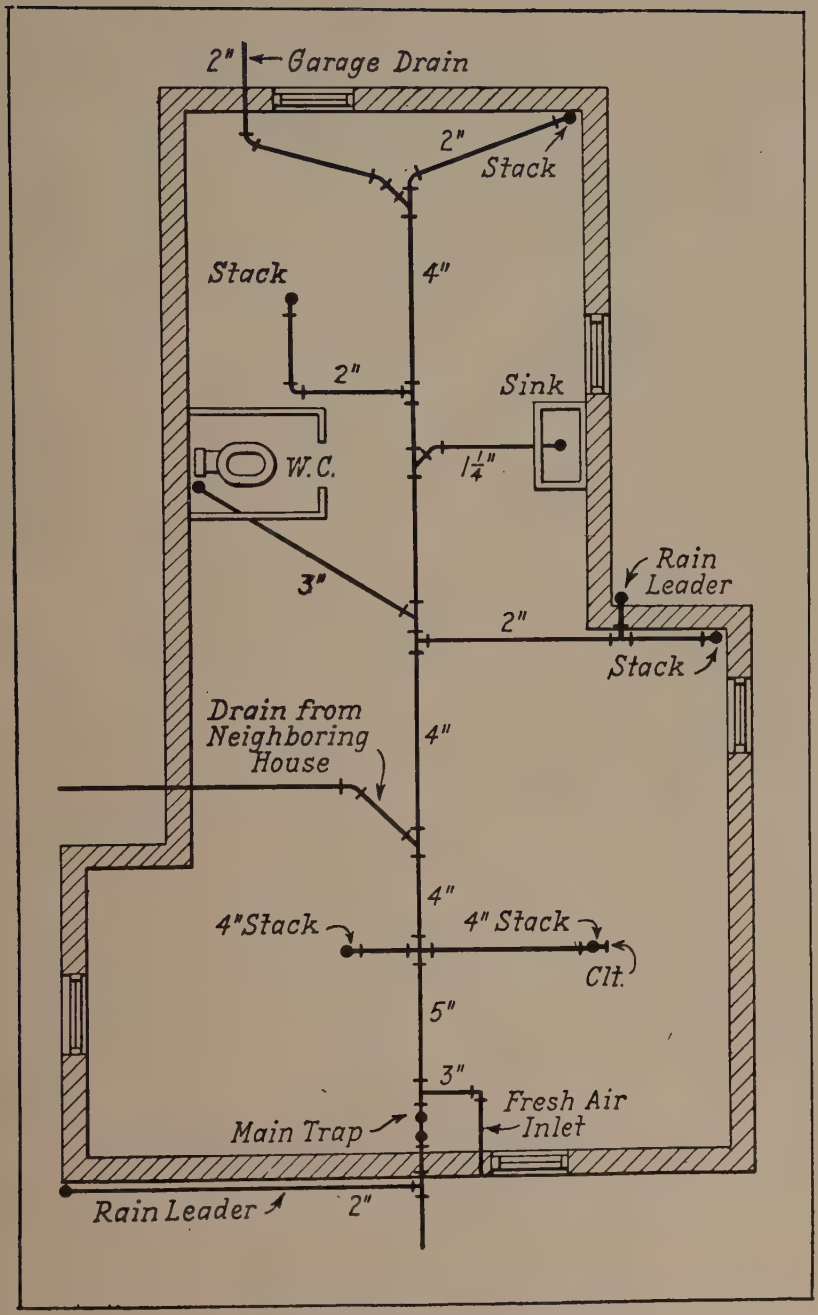


Fig. 350.—Cellar Plan Showing Incorrect Plumbing.

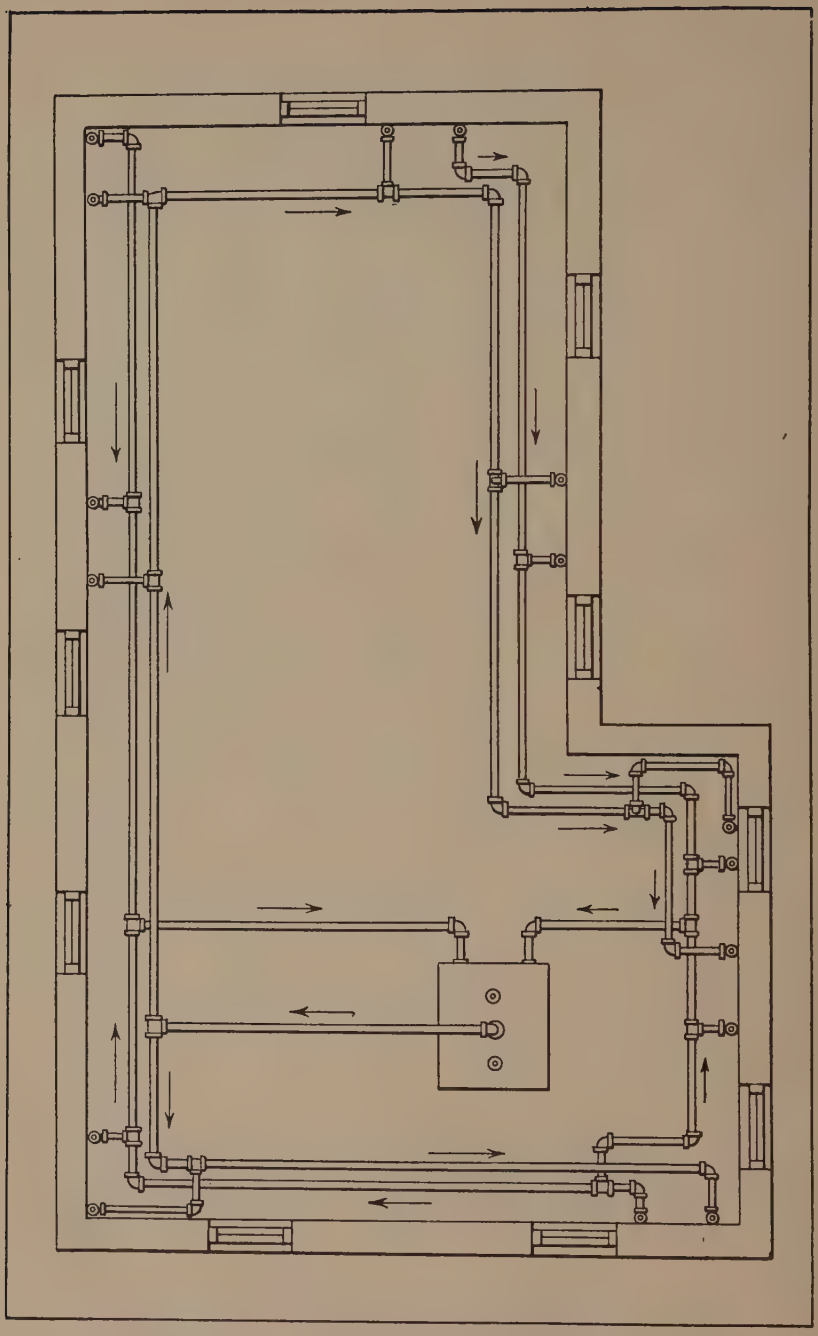


Fig. 351.—Incorrect Two-Pipe Hot Water Heating System.

the other side are the radiators and boiler located in their proper positions, the applicant being required to show the proper piping.

We believe the foregoing illustrations show the chief features of the drawings generally used in the examination of plumbers and fitters, and trust that what we have presented on the subject will be helpful in preparing many young men for the examinations.

CHAPTER XXXII

SOME OF THE FEATURES OF GOVERNMENT PLUMBING

Most of the buildings erected by the United States Government come under the jurisdiction of the Treasury, War and Navy Departments, and through the work of a board especially appointed for the purpose, these three departments have adopted uniform specifications governing plumbing construction in their buildings.

These specifications are covered by nearly sixty different sheets of detail drawings, and may be obtained by those having definite need of them, from the Government Printing Office at Washington.

All of the plates show the use of non-siphoning traps, without trap vents, and the specifications accompanying the drawings call for non-siphoning traps.

The specifications governing the make-up and installation of the various fixtures go into minute detail, but we have not considered that these would be of particular interest to most readers, so we make no attempt to show them here.

The government specifications contain 53 different plates showing various fixtures, appliances and methods.

It will be interesting to give a general idea of the character of these drawings, and with that idea in mind we show Figs. 357 to 364.

Thirteen types of sinks are shown, including vitreous, fireclay, enameled iron, galvanized steel, cast iron, soapstone and planished copper sinks.

In Fig. 357 we show three of these, two of them showing the typical waste connections used on most of these government specifications.

The trap here shown is of cast brass, generally nickel-plated.

Two different bath waste connections are specified, as seen in Fig. 358, one of these showing the bath trap open to view and

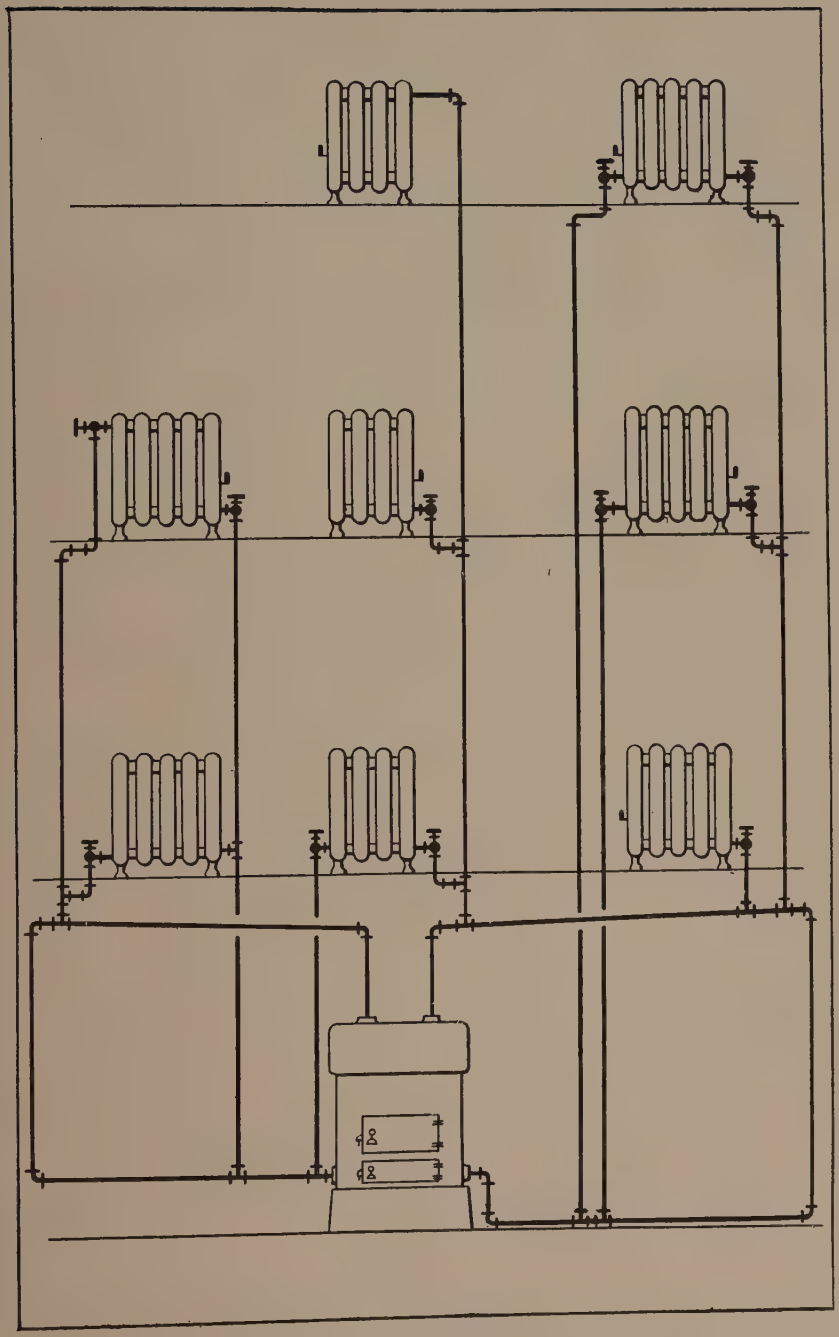


Fig. 352.—Incorrect Two-Pipe Steam Heating System.

above the floor, while the other is of the drum type, and set below the floor.

Eight or nine styles and types of lavatories are specified. The one of most interest is the barracks lavatory, Fig. 359.

This lavatory is of vitreous ware, set up in either of two ways, on cast-iron stands, or on concealed hangers.

Although government work would naturally be supposed to stand above criticism, there are many features of the work shown in these specifications that the well informed plumber would object to. For instance, most plumbing ordinances call for a separate trap under each fixture, and prohibit the use of one trap for a battery of fixtures such as shown in Fig. 359. Moreover, the trap is specified 1½ inches, which seems small, and it is without vent.

Three types of drinking fountain are specified, each of them having integral traps and roll rims. Two of these are given in Fig. 360.

Fig. 361 shows the government slop sink, which is specified vitreous ware, flushing rim, siphon jet, with integral trap. An elevated flush tank is used, also a combination hot and cold water faucet.

Fig. 362 shows one of several of the government specified urinals.

This is of vitreous ware, flushing rim, siphon jet, with double jet arms and trap moulded into the ware.

In Fig. 363 is shown the hot water tank which the government calls for. It may be of various sizes, of galvanized iron or steel, welded or riveted. When provided with steam heating coils, such coils are to be of 16 gauge seamless continuous copper tubing, with inlet at end, and outlet at bottom of boiler. Each boiler has a safety valve or water relief valve set 25 lbs. above high-water pressure, also angle pattern mercury thermometer, graduated from 40 to 240 degrees.

Each tank connected to a coal-burning heater is to be provided with a thermostatic regulator with necessary chains and pulleys to operate the draft door and check draft on the heater, so adjusted as to close the draft door and open the check draft when the temperature of the water in the tank is 140 degrees.

Each tank containing a steam coil is to be provided with a

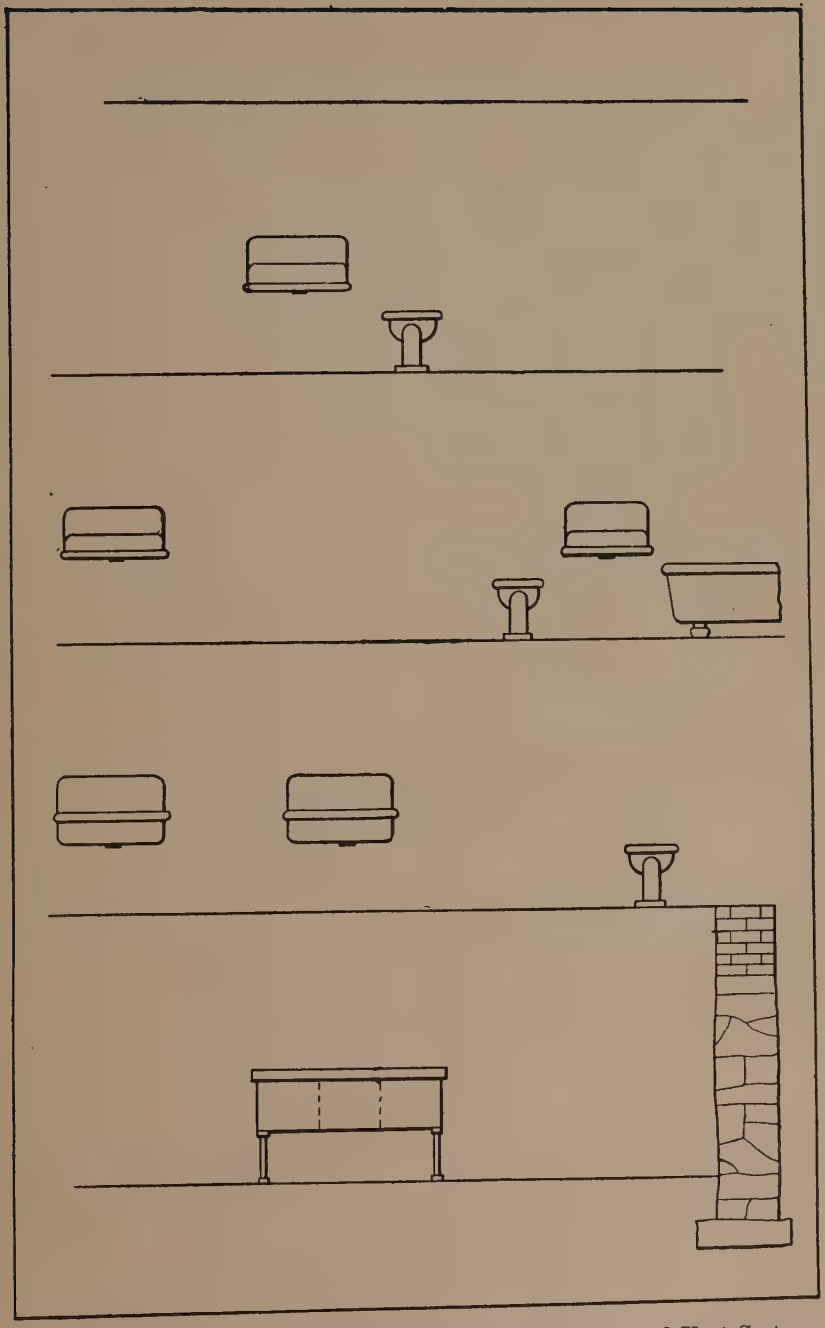


FIG. 353.—Locations of Fixtures Given, to Draw Drainage and Vent System, Using Two Stacks.

thermostatic regulator with necessary connections and valve to control the steam supply to the coil, adjusted so as to close the steam valve when the water in the tank is at 140 degrees.

Either of two types of regulators is acceptable, viz.: one that controls the steam supply to the coil and operates the draft dampers, or one that requires a regulator for the steam valve to coil with an independent regulator to control the dampers on the heater.

Fig. 363 shows horizontal boilers, one suspended on wrought iron hangers from the ceiling, the other supported from the floor on a pipe stand.

Fig. 364 shows a vertical hot water tank supported on a four-leg stand. In general the specifications are similar to those named above, for Fig. 363.

The regulator shown in Fig. 364 consists of a double chamber box inserted in a short-circuit pipe connection between flow and return pipes, the inner chamber to contain a volatile liquid, the vaporization of which exerts pressure sufficient to operate regulator lever direct or through a diaphragm valve.

Another form of regulator that may be used consists of a tube inserted in the tank, made up of an expanding tube containing a non-expanding member, the expansion and contraction of the former operating a diaphragm valve, which permits the water supply to operate a secondary diaphragm valve controlling a regulator lever.

Many other features concerning government plumbing specifications might be brought out if space permitted, but we have given enough of them perhaps, to show in general what their good features are, as well as their shortcomings.

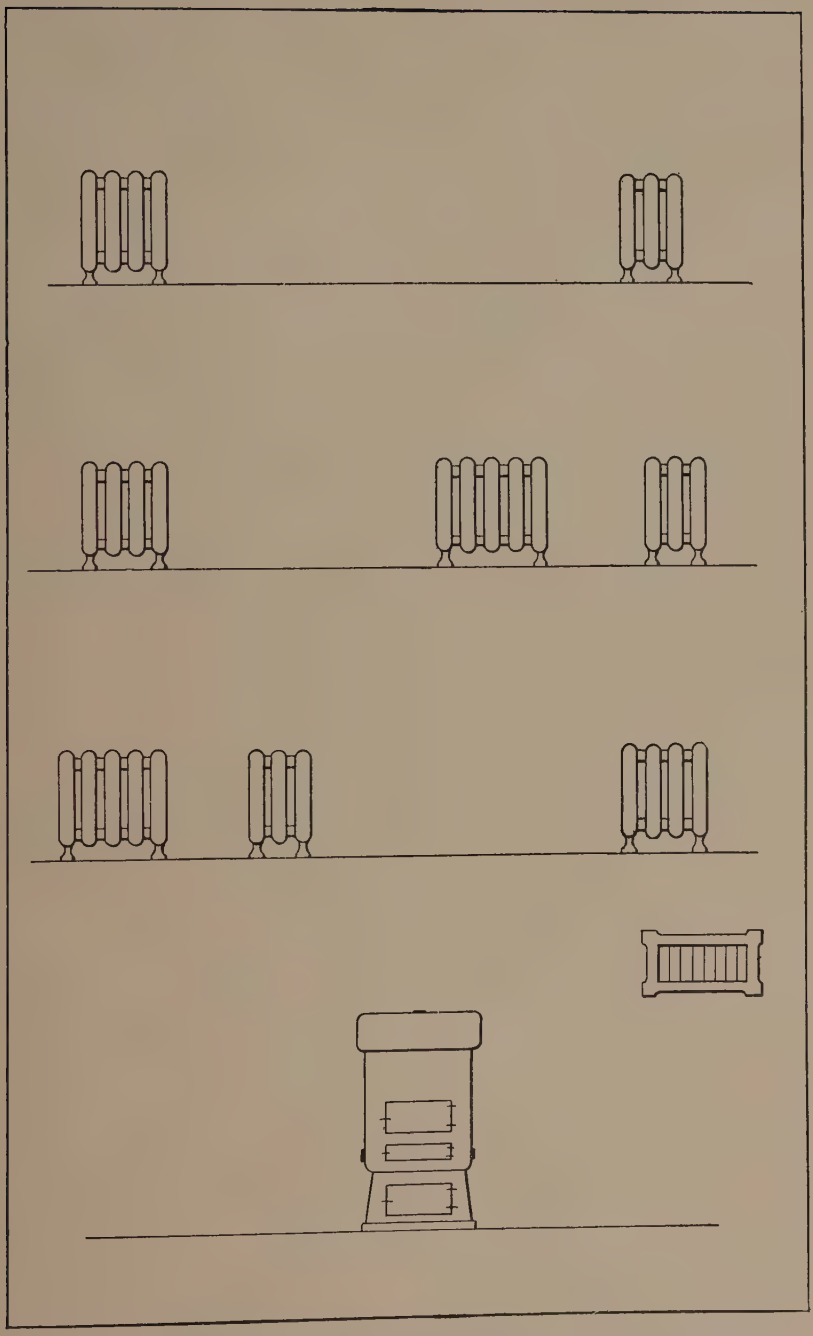


FIG. 354.—Locations of Heater and Radiators Given, to Draw Connections for Heating System.

CHAPTER XXXIII

SUBJECTS OF INTEREST CONCERNING PLUMBING PRACTICE, COVERED BY THE REPORT OF THE SUB-COMMITTEE ON PLUMBING, OF THE BUILDING CODE COMMITTEE, APPOINTED BY THE UNITED STATES DEPARTMENT OF COMMERCE

It is generally well known throughout the plumbing trade, that a great fund of information on plumbing is to be found in the U. S. Government report, published in 1924 by the Department of Commerce.

The title of this report is "Recommended Minimum Requirements for Plumbing in Dwellings and Similar Buildings."

The work which underlies the report, was done by a commission of distinguished sanitary engineers appointed by Secretary Hoover to serve on the Sub-Committee on Plumbing of the Building Code Committee. Their work of investigation and experiment extended over a period of two years or more, dealing with many of the most vital questions of plumbing practice.

The results obtained by this commission reflect the highest credit. The work was carried on in an unprejudiced way, and in a most practical and scientific manner.

As a matter of fact, we are firmly of the belief that the publishing of this government report marked one of the greatest forward steps that has ever been taken in the history of the plumbing trade.

The report should be in the hands of everyone connected with plumbing, and we are glad to state that it may be obtained for 35 cts. from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The report by the way, is a 260 page volume, fully illustrated.

In several of the author's other books, allusion is made to this

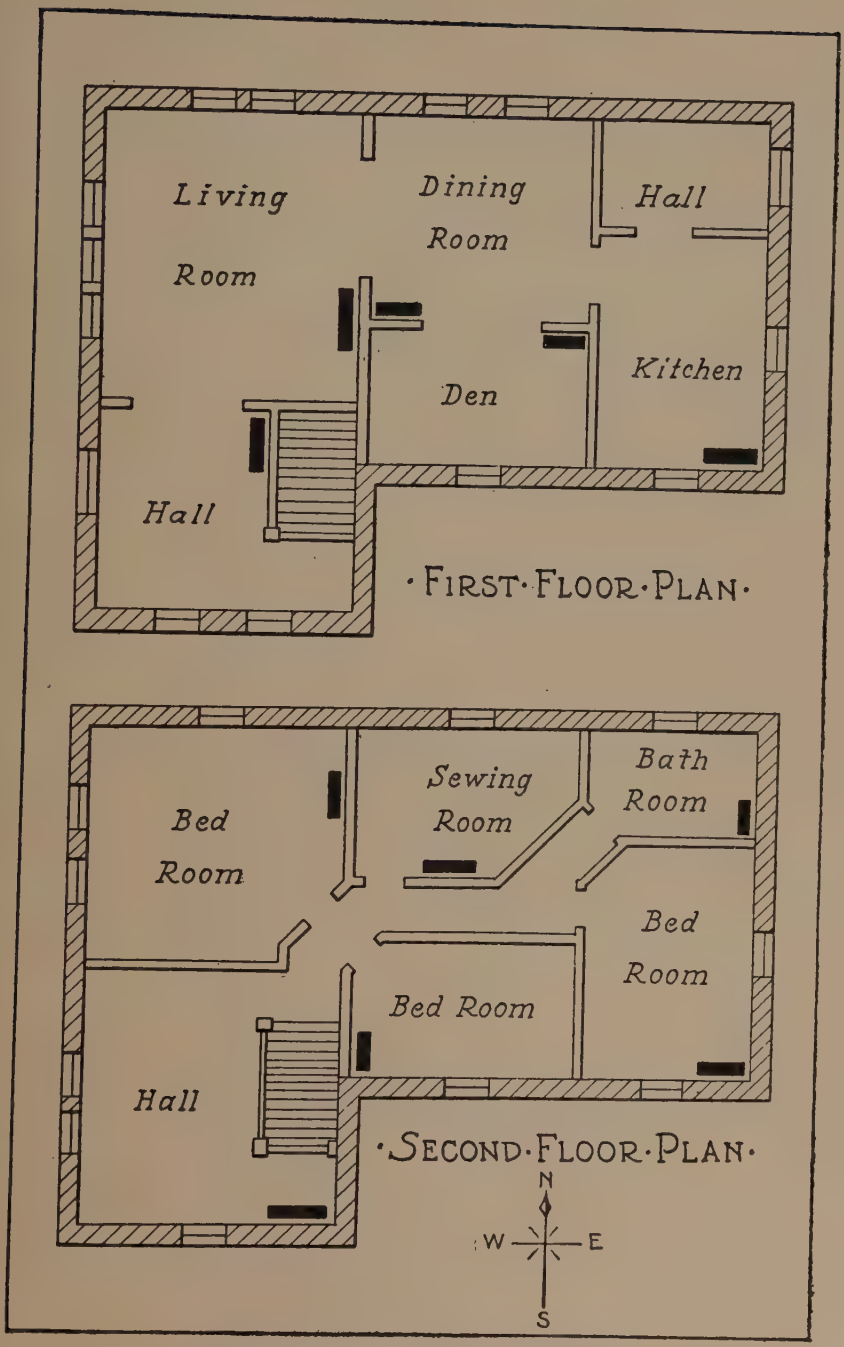


FIG. 355.—Incorrect Locating of Radiators.

report, and considerable information contained in it has been shown, due credit being given to the source from which it came.

In this chapter we think it will be of much value to give our readers some additional information taken from the report.

It may be well to state that perhaps the leading thought back of the work of the Sub-Committee, has been the simplification of plumbing construction, without affecting its present efficiency, and this seems to us to have been a high aim.

The siphonage of fixture traps was one of the subjects investigated, and as we all know, this is one of the fundamental subjects in plumbing.

We quote the following from the report;—

Siphonage of Fixture Traps

"Careful study has been made of the action of plain traps; that is, the ordinary S, ¾ S, and half-S or P traps, under different conditions. The efficiency of a trap is sometimes thought to mean its resistance to loss of seal, but the real efficiency is resistance to alternate suction and back pressure. Loss of seal does not concern the trap alone. The fixture itself is an element when self-siphonage is being considered. A trailing discharge, such as occurs in a bath tub, kitchen sink, or laundry tray, is almost invariably sufficient to refill an ordinary trap; but with an oval basin, where the discharge ends suddenly, greater care must be taken to prevent self-siphonage. The diameter of the tailpiece relative to that of the trap is an element. There are advantages in having the tailpiece one nominal size smaller than the trap. The length of the waste pipe and its inclination to the horizontal are also elements, as well as the presence of elbows in the waste pipes. Hence, it is more logical to consider the efficiency of the trap and waste pipes as a whole, than that of the trap alone, using the changes in trap seal as a measure of the efficiency of the system.

With this idea in mind, extensive studies were made to ascertain the effects of pressure, aspiration and self-siphonage on the seal of traps, and the best arrangement of designing waste pipes to secure an efficient system in the simplest way. The possible situations are so numerous that the reader is referred to the detailed statements and diagrams in Dr. Hunter's report. The com-

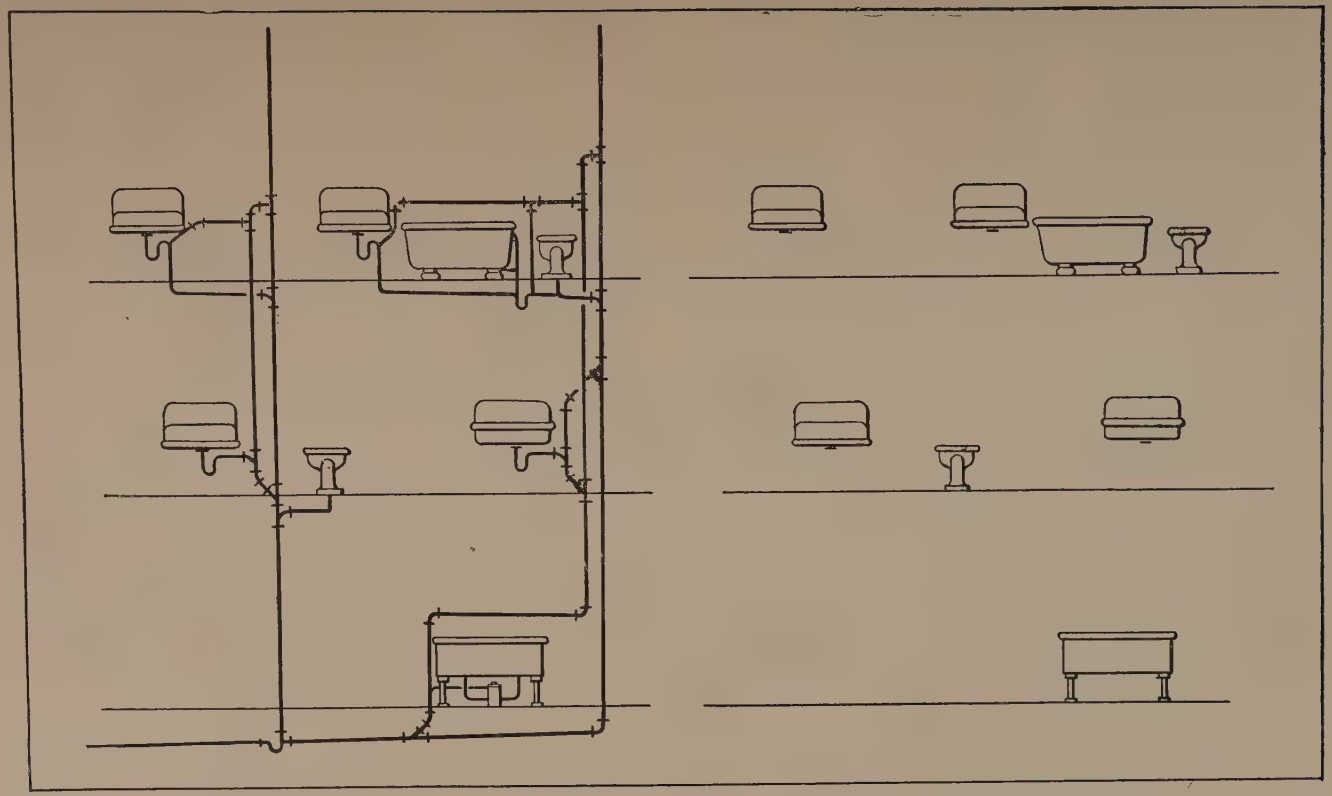


FIG. 356.—Incorrect Drawing of Plumbing to be Re-drawn Correctly on Opposite Side of Sheet.

mittee reached the conclusion that the minimum seal for a plain trap should be 2 inches, and that a loss of seal greater than 1 inch in such a trap, should be regarded as unsatisfactory. While it is true that a seal is not actually broken unless the water in the trap falls below the "dip", some factor of safety must be allowed to provide for unexpected shocks, for evaporation, capillary loss, and for oscillations due to wind pressure, while a lowering of the seal exposes a foul surface on the house side of the trap.

A fixture trap is almost sure to foul to some extent; sediment may collect at the bottom, grease may adhere to the sides, and growth of fungi may develop. The deeper the trap seal, the greater the extent of the fouling. While deep-seal traps can withstand siphonage better than traps of shallow seal, these other practical considerations combine to make it advisable to place a maximum limit upon trap seals, and the committee has placed this at 4 inches. Experiments and computations made by Mr. Howland (appendix C) have shown that the danger of gases in the drainage system diffusing through the trap seal is negligible for water seals between 2 and 4 inches; that the liability of odors from deposits in the trap is also negligible; but that the possibility of odors from deposits on the pipe between the fixture and the trap in the overflow waste pipe and in the trap itself when its seal is lowered below normal, is more important. While it is true that many traps which have seals as deep as 6 or 7 inches are in use, and while such deep-seal traps cannot be said to be injurious to health, the committee is of the opinion that the establishment of a minimum limit of 2 inches and a maximum limit of 4 inches for plain traps is desirable, and gives a basis for standardization."

The question of correct depth of trap seal has always been highly debatable. Some felt that a deep-seal trap is to be preferred, owing to the fact that it withstands siphonage more successfully, while others felt that the deep-seal trap was objectionable because of its greater liability to fouling. In view of this situation, it is a most satisfactory thing to have it so fully demonstrated, that the best depth for the seal of a trap is between 2 and 4 inches. but neither less nor greater than these depths.

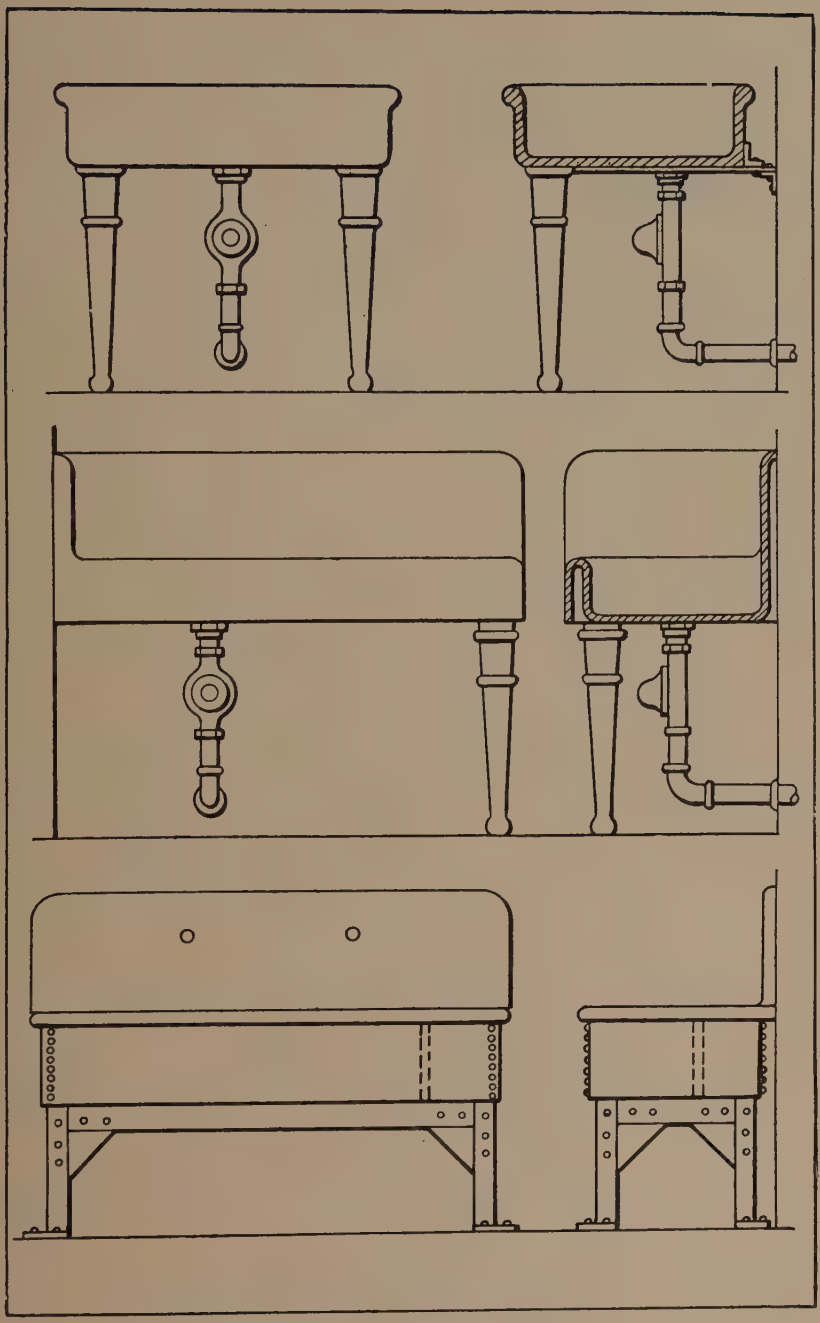


Fig. 357.—Three Types of Sinks.

Another excellent feature of the report concerns venting, as follows;—

Vent Requirements

"The subject of venting is complicated, and cannot be discussed in a few words. The committee has given attention to the necessity of relieving back pressure, partial vacuum, and self-siphonage of traps, in order that a plumbing system may function efficiently. It has also made studies of air circulation and diffusion. The experiments have been very numerous, and the results can be understood only by giving careful study to the particular arrangement of pipes in each case. The committee suggested as a criterion of satisfactory trappage, that the 2-inch seal of a trap should not be reduced to less than 1 inch. Stacks of 3 and 2 inches were chiefly used.

Speaking in general terms, it may be said that the size of the vent stack depends upon three principal factors—the diameter of the soil pipe, the maximum volume of water discharged, and the length of the soil and vent stacks. Specifically it was found that for a 3-inch stack carrying its capacity load of 26 fixture units, a 2-inch vent 36 feet long, or a 1½-inch vent 15 feet long, gave satisfactory results.

The flow of air in pipes is the controlling factor in vent requirements. Use was made of well-known pneumatic laws for air flow, and these laws, together with the experiments themselves, gave the basis for some important generalizations in regard to the design of vent stacks. Given the discharge and the developed length of vent stack, the diameter required for a given soil stack can be determined. Increasing the diameter of a soil stack requires greater proportional increase in the diameter of the vent stack, because of the increased volume of air to be moved. On the other hand, decreasing the diameter of a soil stack permits a greater proportional decrease in the diameter of the vent stack, but there are objections to using a vent stack less than 1¼ inches in diameter."

Also on the subject of venting, the report contains the following;—

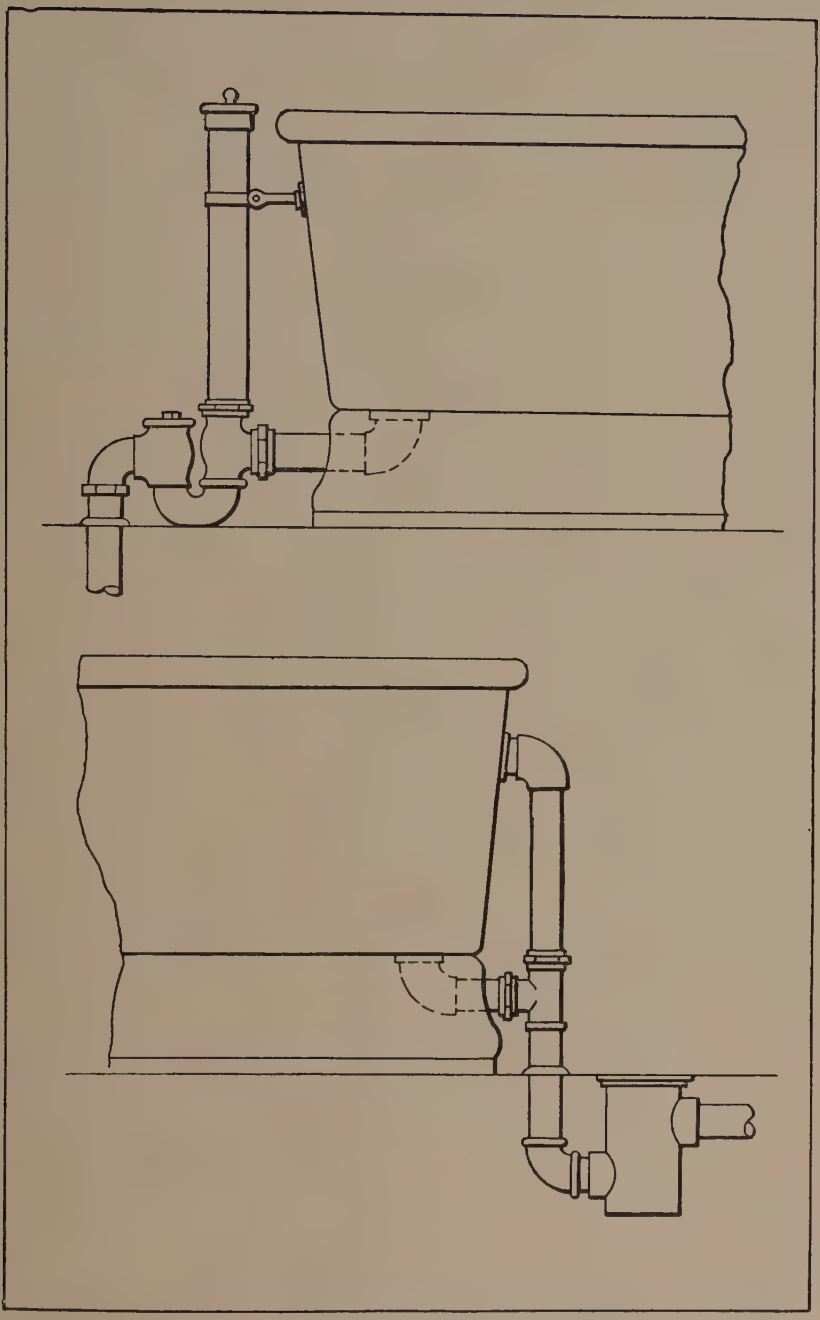


Fig. 358.—Bath Waste Connections.

Unvented Horizontal Branch Waste Pipes

"Directly involved with the question of resealing traps is that of the allowable length of unvented horizontal branch waste pipes, because it is chiefly in connection with long branches that resealing traps have an advantage over plain traps.

Long branches have a number of practical disadvantages. There is a tendency to give them too little slope. Long straight runs are likely to interfere with framing timbers and encourage unnecessary cutting. If the fixture discharge is small, and only partially fills the pipe, deposits may occur, and if the discharge is so large as to completely fill the pipe, self-siphonage of the trap may occur. It is this last danger that the resealing trap is supposed to prevent. If a long branch becomes stopped, it is more difficult to clean than a short branch.

If long branches are unvented, there is danger of corrosion. While this is well known by experience, especially where wrought iron or steel is the metal used, the committee thought it worth while to have this subject studied. The results of the experiments show that in unvented horizontal branches connected to a stack, the movements of air in the stack produce eddy currents in the branch to a distance of only 1 or 2 feet; that temperature changes may cause slight air movements in the branch; that diffusion of gases throughout the length of the branch occurs; that if such a gas as carbon dioxide is produced from deposits of organic matter uniformly along the branch the maximum concentration of this gas will increase as the square of the length of the branch; that deposits of moisture occur on the inner walls of a pipe, especially along the top; that iron rust absorbs moisture; that moisture thus collected absorbs carbonic acid, which tends to stimulate the corrosion of iron. In other words, the danger of corrosion in an unvented branch 10 feet long is about four times as great as in a branch 5 feet long. In the case of exposed horizontal pipes, leakage from corrosion might be detected and the pipe could be readily replaced, but waste pipes are usually concealed, where leakage might go undetected and replacement would be costly.

From the standpoint of self-siphonage, the slope should lie between one-eighth and one-half inch per foot, and the outlet should

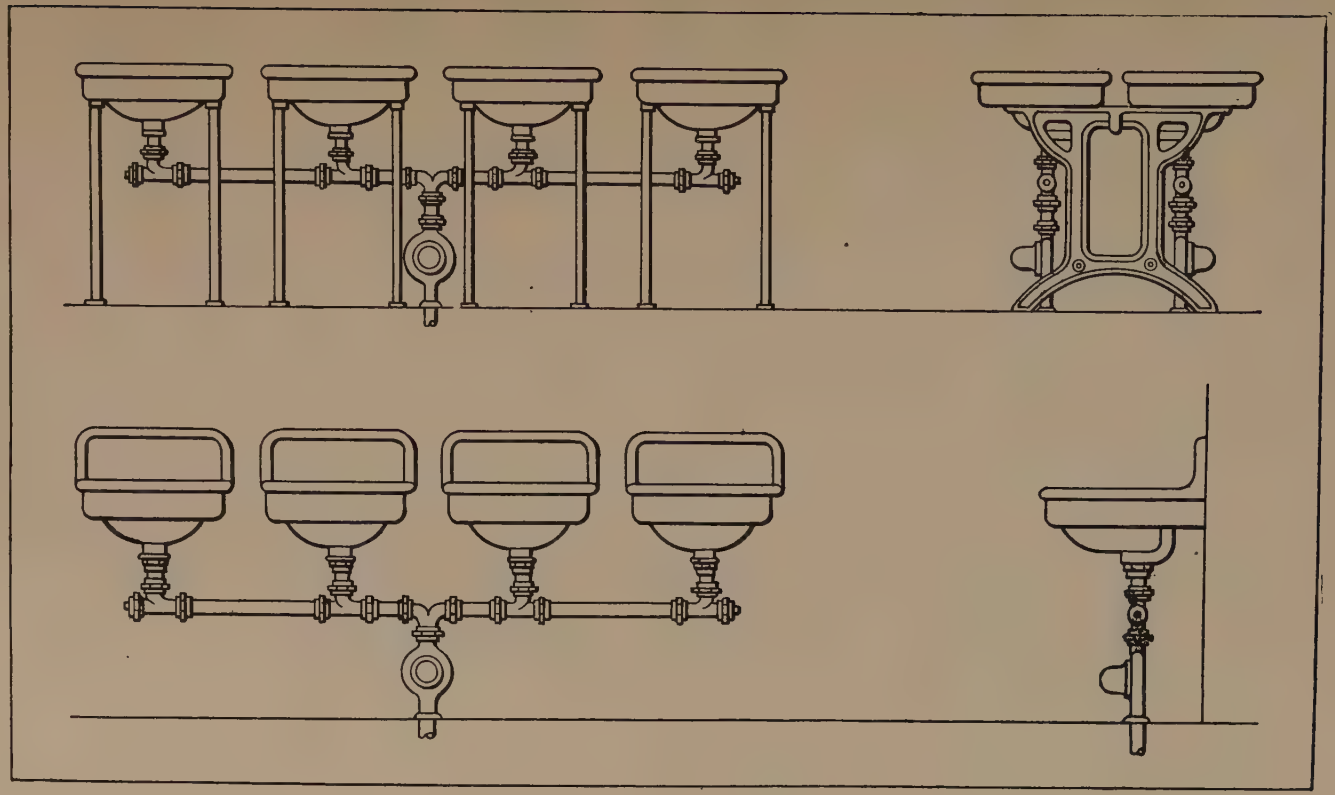


Fig. 359.—Barracks Lavatory.

not be below the dip of the trap. Doctor Hunter's experiments show that in the case of wash basins, plain traps of 2 to 4 inch seal, connected to horizontal wastes of 4 to 8 feet, would be safe against siphonage, and in the case of wide bottom fixtures, the lengths might be about twice as long, with one 90° elbow not more than 18 inches from the trap. But on the basis of all the evidence at hand, the committee decided that 5 feet should be established as a reasonable limit for the length of an unvented horizontal waste, measured horizontally from the vertical inlet of the trap to the vent opening."

Venting of Branch Wastes

"A clogged vent pipe is useless, just as useless as if no vent pipe had been installed. If waste pipes are so arranged that the waste water may rise into the vent pipe at times of discharge, the latter is very liable to become clogged. If the connection of the vent pipe and waste pipe lies below the hydraulic grade—that is, below a line which connects the high-water line of the fixture and the point where the waste pipe enters the stack—water is likely to rise into the vent pipe. The crown vent is an example of this condition, and the frequent clogging of this vent has caused this arrangement to be looked upon with disfavor and even to be prohibited by regulation, but almost any vent which rises from a horizontal branch may act in the same way, if the discharge fills the waste pipe. If the vent forms a continuation of the vertical leg of the waste pipe, and if this connection is above the hydraulic grade, there will be no danger of the vent becoming clogged. This is a reason for limiting the length of all horizontal waste pipes, whether vented or not. Doctor Hunter's explanations of this subject are clear and illuminating."

One of the leading features of the government work was the idea of the simplification of the plumbing system. In fact, a statement to this effect is made in the early part of the report. At the same time, it is recognized that simplification must never be at the expense of efficiency. It seems to us that this sort of simplification has been attained in the conclusions and recommendations

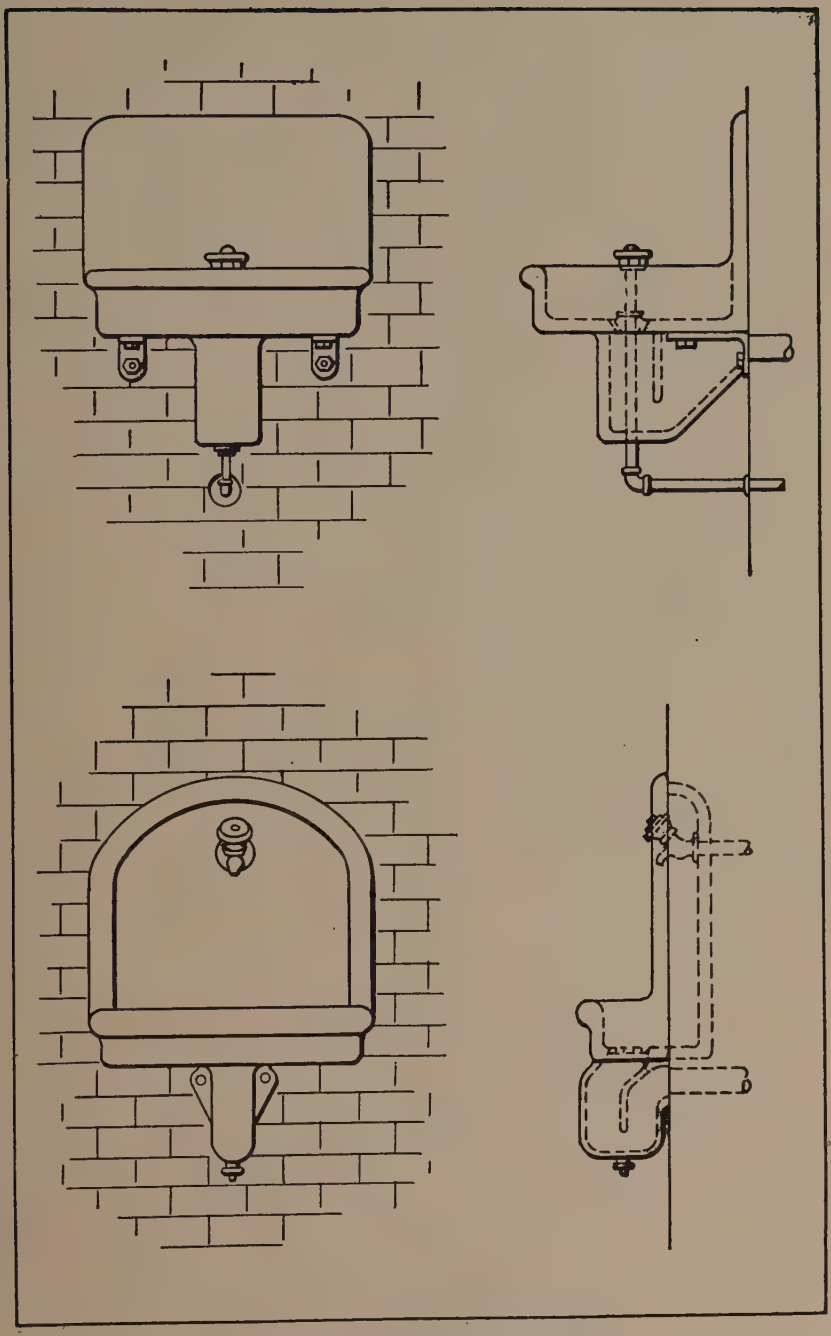


Fig. 360.—Drinking Fountains.

reached by the government commission. This opinion on our part is borne out for instance, in the following paragraph;—

Separate Trap Venting Not Necessary

"Every trap seal of a plumbing system should be adequately protected against failure, but to accomplish this, it is not necessary that each particular trap have an individual vent pipe. For example, stack venting appropriate for the highest fixtures, is the most efficient and certain of all forms of venting. Venting requirements relate to the drainage system as a whole. Wet vents—that is, portions of the waste pipe which are used alternately for the discharge of water and for venting purposes—are unobjectionable if installed with regard to the principles already set forth."

In the cold sections of our country, it is a well-known fact that accumulation of frost in the soil pipe extension through the roof, will sometimes entirely close the opening, thus closing the circulation of air through the vent system to the fixture traps. This result has to be guarded against by increasing the size of the pipe in passing through the roof. The general practice is to increase 2-inch and 3-inch stacks to 4-inch, the 4-inch stacks continuing through the roof full size, or increasing to 5-inch in some cases.

What the government work discloses on this subject is interesting, and is as follows;—

Frost Closure of the Stack Tops

"The closure of the top of the stack by frost or other cause was studied. Complete closure caused some of the traps to be siphoned by the discharge of a single water-closet, and this occurred whether or not the traps were individually vented. Incomplete closures gave less noticeable effects.

It is a matter to be guarded against as well as possible, but cannot be controlled by modifications of the venting system."

One of the subjects that came to the attention of the commission was the manner in which water falls in partially filled stacks. The part of the report dealing with this subject is as follows;—

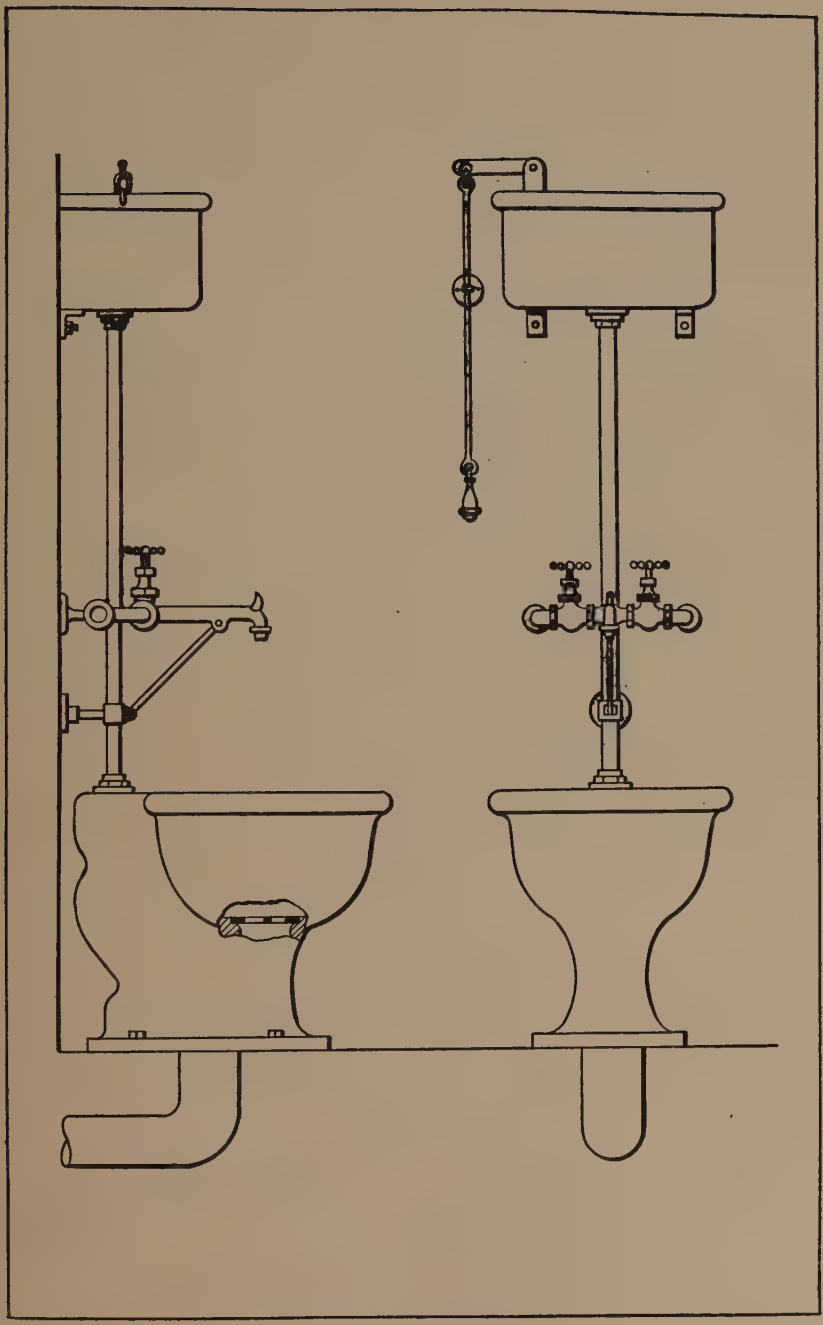


Fig. 361.—Slop Sink.

Characteristics of Fall of Water in Partially Filled Stacks

"Small flows of water down a stack tend to adhere to the sides and to follow a spiral course. In the case of large flows, frictional resistance of the air causes the water to form diaphragms across the pipe, which persist temporarily, and then break through. With still larger flows, the diaphragms become slugs and do not break through. Solids tend to encourage the formation of slugs.

The studies of velocities in partially filled pipes were interesting and instructive. The acceleration of falling water under the influence of gravity and the friction of the water on the sides of the pipe, which increases approximately as the square of the velocity, unite to produce a velocity which, after it attains a certain maximum, remains practically constant. This maximum is reached in a comparatively short fall and increases as the volume of flow increases. This whole subject of vertical velocity is a matter of importance in the design of tall stacks, and the studies indicate that the height of stacks need not be limited because of the fear of excessive downward velocities. For example, in a 3-inch stack open at both ends, the velocity attained after a fall of 20 feet is 29 feet per second, and after 100 feet 34.2 feet per second, a relatively small increase. Doctor Hunter's experiments and computations are a valuable contribution to hydraulic science in this field."

The government commission among its many researches, investigated the subject of admitting roof drainage to the house drainage system, this section of the report being the following;—

"There are advantages in not admitting roof water to an interior house drainage system. If the city has a "separate" system of sewers—that is, domestic sewage and rain water kept apart,—the admission of roof water to the house sanitary sewer would not be allowed. If the city has the "combined" system, the storm water should be carried separately to the house sewer. There is a tendency to change from the combined to the separate system, and if this were done, the cost of alterations in the plumbing required to bring about the separation would be much greater if the

roof water entered the house drain than if it entered the house sewer outside the building.

The admission of roof water to a house drain increases the danger of back pressure near the base of the stack, this danger increasing rapidly with the rainfall. In its computations, the committee considered that a rainfall of 4 inches per hour was a reasonable allowance, and hence it was decided that 180 square feet of drained area in horizontal projection should be considered as equivalent to one fixture unit. The method of applying this figure to the table given in the code, allows a large factor of safety.

This figure was reached after a careful study of the frequency of occurrence of different rates of rainfall in different parts of the United States, as published by the Weather Bureau of the United States Department of Agriculture. At New York a 4-inch rain lasting one hour occurs once in about two years; at New Orleans, every year; and at St. Paul, Minn., once in three years. Where large systems are being designed, the committee's reasonable allowance should not be used, but some other figure based on a careful study of local rainfall intensity should be substituted for it.

In computing the capacity of a house drain, this rain allowance should be added to the other requirements, for although the chance of such a rainfall as that assumed occurring at the time of the peak load from the fixtures is small, the factor of safety thus provided is none too large.

Storm water, a high tide, or sewer stoppage may cause the house sewer or even the house drain to be submerged, giving back-pressure effects similar to those produced by admitting roof water to the system. Where such complications as this are likely to occur, the committee favors a distance of at least 3 feet between the lowest fixture inlet to the stack and the house drain."

Almost anyone who has had an extended experience in the plumbing business knows that various provisions found in plumbing codes have been attacked through the courts, and these attacks have often been successful. To such an extent is this true, that in many cases plumbing codes have lost a large part of their force, and have been allowed to remain largely unenforced.

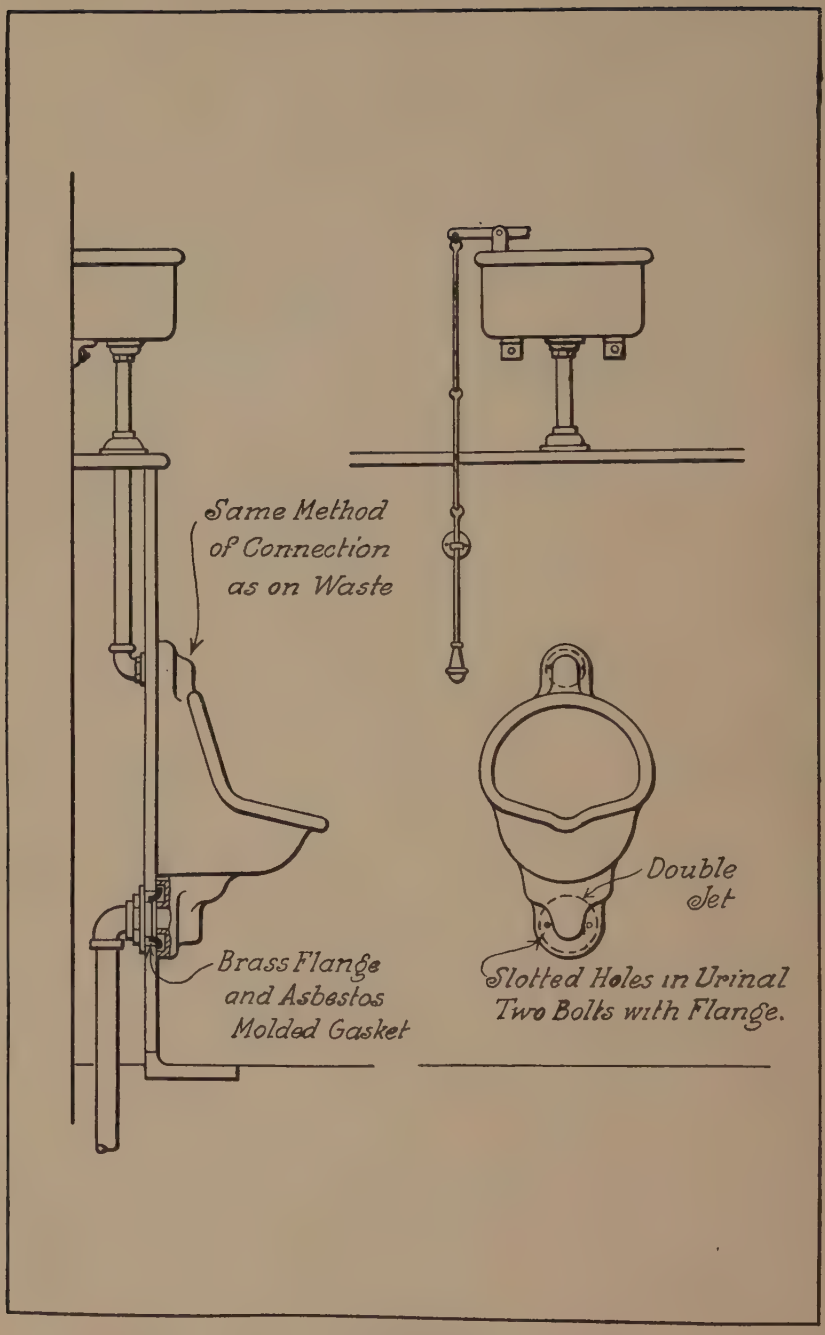


Fig. 362.—Urinal.

Today the importance of a plumbing code correctly established from a legal standpoint, is a matter of very great importance.

So far as we know, the legal features connected with a successful plumbing code have never been fully and clearly defined and presented to the plumbing trade in an understandable manner.

It is with great satisfaction therefore, that we are able to find in the government plumbing report, an exceedingly clear statement concerning the entire situation. We give the subject completely, just as presented in the report.

Legal Principles

"It is impossible to study the subject of plumbing regulation without having a proper conception of the common-law principle known as "police power", for, though a part of the common law, and without absolutely definite limits, it can and must control court decisions, without which plumbing regulations would be futile. Attention should be called to the fact that this legal term, "police power", does not mean the power of a policeman. It is true that the policeman, with his uniform and his stick, is one agency for enforcing the "police power", but plumbing inspectors, building inspectors, fire marshals, and health officers also act under the same "police power". Police power is that inherent power of government which protects the people against harmful acts of individuals, in so far as matters of safety, health, morals or the like are concerned. "Police power" is "community power". Injuries against health come within the proper scope of the police power; but acts of government to enhance or promote health above normal, while laudable and often justifiable, do not fall within the scope of the police power.

There is a difference between conferring a benefit and preventing an injury, which though difficult to define, is nevertheless real. Some of the requirements now generally included in plumbing codes, represent a failure to make this distinction properly, and cannot be justified as essential to the protection of the public health from injury.

When there is difficulty in enforcing such regulations, and the cases are brought into court, it often happens that the code requirements are not supported. In this way well-meaning citizens

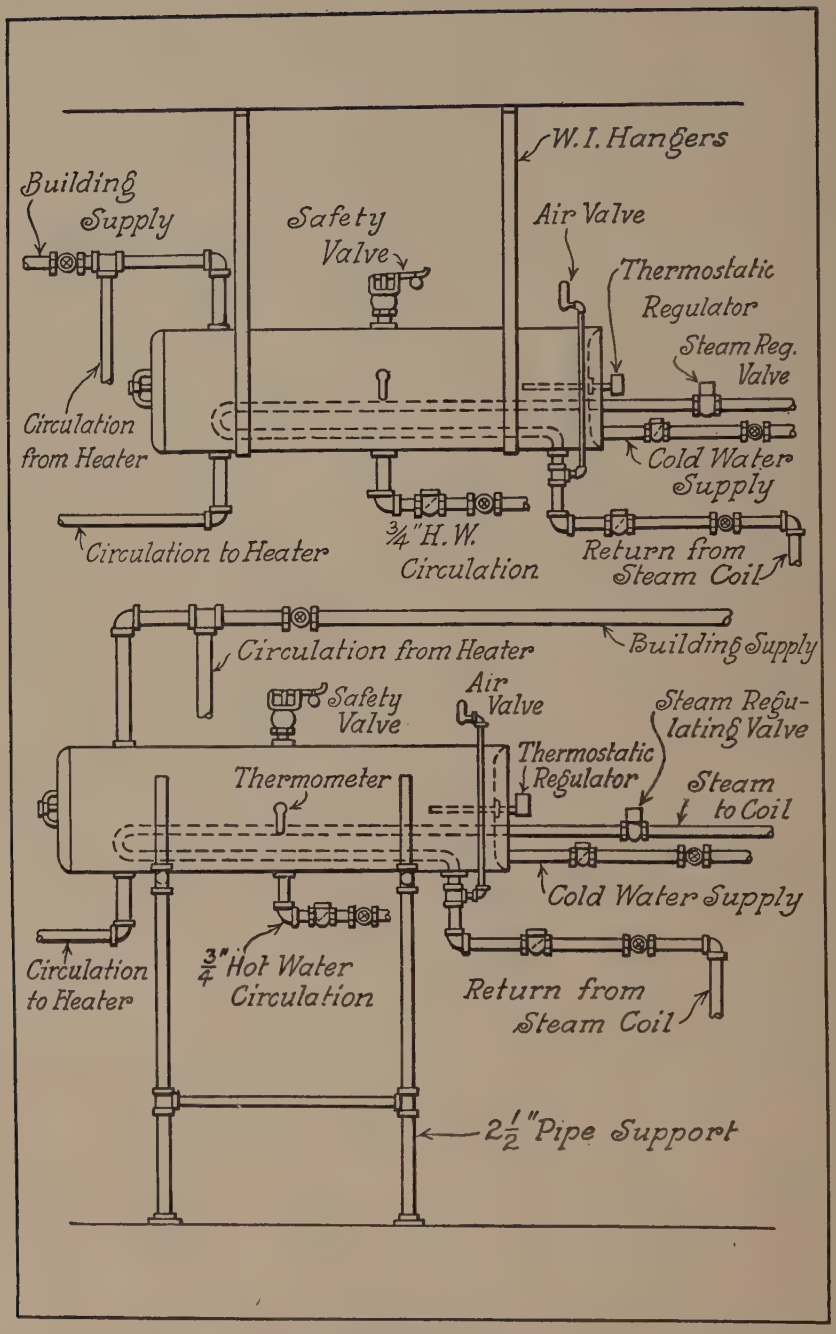


Fig. 363.—Hot Water Tanks.

comply with regulations which cannot be enforced upon the unwilling citizen, and injustice results.

Unfortunately this situation exists today. Plumbing regulations therefore, should be carefully examined in the light of modern sanitary science, and accepted legal principles, to determine their legality, keeping in mind that in so far as they protect the human health against injury, they are justifiable, but no farther.

It should be observed also, that legally the police power has to do with "health", not merely the "public health". This is a distinction which even a health officer often fails to make.

The following principles may be considered as safe guides in the matter of governmental control:

1. The control of plumbing by government is distinctly an act done under the police power, because it has to do with protection of the health of the people against injury, using this term in its broad and popular sense.

2. This use of the police power resides fundamentally in the state governments, but may be and often is delegated to cities, towns, or other subdivisions of states.

3. The police power has not been delegated to the federal government, except so far as needed to carry out certain delegated powers (as for example, quarantine); hence, the federal government has only advisory powers regarding its employment by states.

4. The use of the police power in plumbing regulations is justified on the theory, supported by scientific evidence, that the passage of rats, cockroaches, water bugs and other vermin in and out of drains, or the escape of sewage or of air from drains or sewers into occupied human dwellings, are menaces to health, using this term in its broad and popular sense.

5. Plumbing regulations cannot legally contain requirements which do not, either directly or indirectly, prevent injury to health, safety, morals or the like. No requirements can legally be made, which have to do merely with economies of construction, with benefits to the house owner or occupants, or with benefits to manufacturers, traders or laborers, for the right and only legal use of the police power is to protect against injury.

6. The design of plumbing systems is properly within the scope of legal regulation in so far as it has to do with the escape of solids,

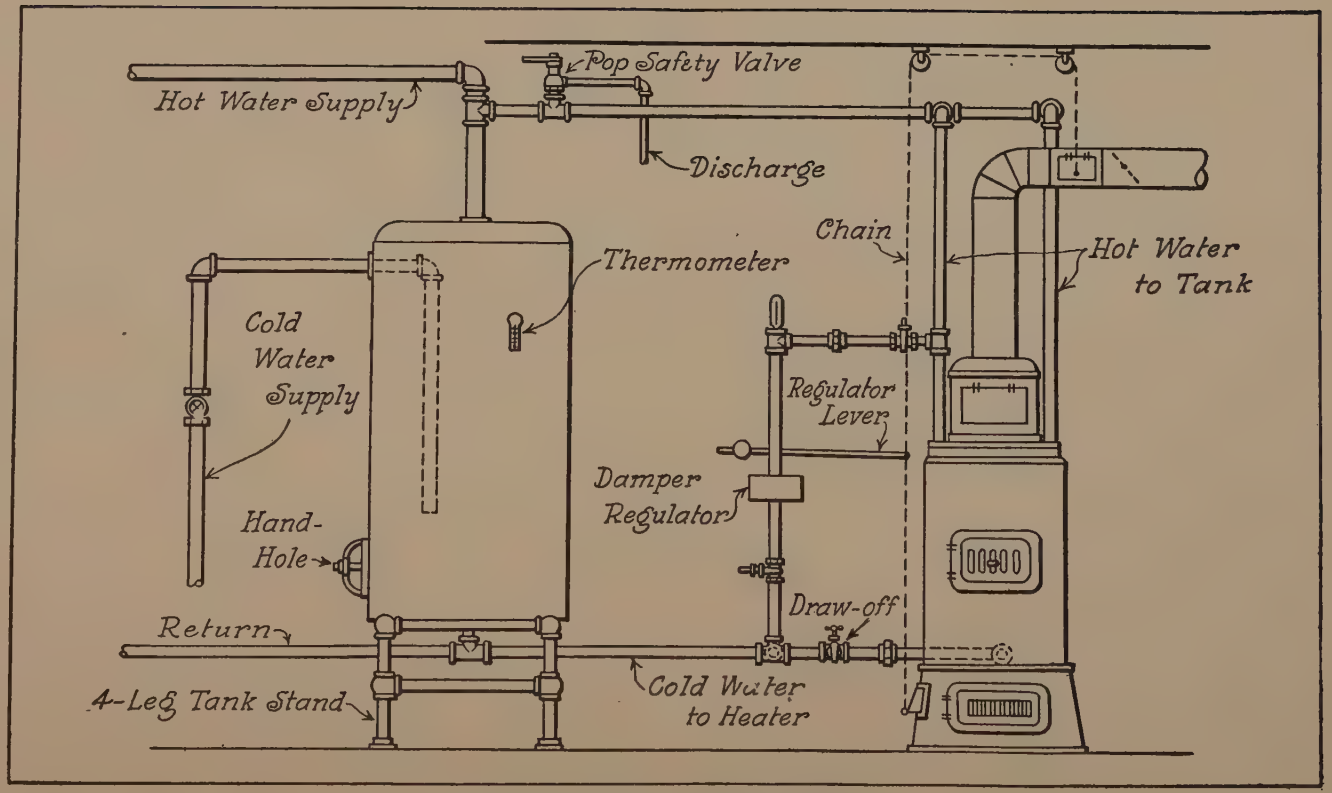


Fig. 364.—Hot Water Tank and Heater.

liquids or gases from, or the access of vermin and insects to drains and sewers, in such a way as to endanger health, and in so far as a safe and adequate supply of water to the fixtures is concerned.

7. Plumbing materials are properly subject to legal regulation in so far as their reliability in preventing dangers to health is concerned, looking ahead to a reasonable life of the building.

8. Methods of plumbing construction are properly subject to legal regulation in so far as they may be necessary to guard against danger to health through faulty workmanship.

9. The control of plumbing by the system of permit and inspection and test is a logical and apparently a satisfactory way of guarding against injury to health through faulty plumbing; but in view of different conditions existing in large and small communities, the states should delegate to local communities the manner of administrating this control.

10. The system of examining plumbers is for the public benefit and should be continued, but it might be better for the examining authorities to issue certificates of competency rather than "licenses".

11. The requirement that plumbing work, subject to permit and inspection, be done by licensed plumbers, is justifiable under the police power.

12. Uniformity in methods of plumbing control is desirable, as it makes for convenience and economy. Uniformity can be secured by following models set up by federal or state governments.

13. Standardization of plumbing designs, so far as dimensioning is concerned, standardization of plumbing materials, and even standardization of code requirements are for the public benefit, rather than for protection against injury, and should be brought about by agreement and concerted action. They cannot be required legally under the police power.

14. As the police power resides in state governments and as uniformity in plumbing regulation is for the public benefit, it is well for all states to have simple, uniform state-wide plumbing regulations alike in essential respects, limited to matters which properly come within the scope of the police power under a wide range of conditions, with provision for permitting local communities to regulate installation and inspection by such methods as they

see fit to adopt. These may be appropriately called "basic plumbing principles".

15. The residence or dwelling is the basis for plumbing codes, because the majority of all buildings are of this type. A code applicable to dwellings is also applicable, although not necessarily sufficient, for other classes of buildings.

Buildings differ as to plumbing conditions, so that different regulations for different classes of buildings are fully justified under the police power. In fact, to apply the same regulations to different conditions; that is, to require practices necessary in one case for another case where they are not necessary, is an improper use of the police power. The fourteenth amendment to the constitution of the United States provides for "equal protection of the law", but equal protection means under like circumstances.

16. In addition to the basic plumbing principles, it is well for each state to adopt a code of plumbing rules conforming substantially to that hereinafter recommended, which has been so drawn that compliance therewith will practically assure compliance with the basic plumbing principles.

17. It is a well established principle in drawing specifications for works which involve operation that guaranteed results and detailed methods of construction should not both be specified at the same time.

If certain guaranteed results are demanded, the contractor should be allowed some latitude in construction, and if detailed methods of construction are specified, it should be expected that the desired results will follow as a matter of course.

Similarly, if reliance is placed on a general code of basic plumbing principles, there should obviously be freedom of choice as to many details; whereas if cities or towns choose to adopt a more rigid and detailed set of requirements, compliance with them should be regarded as prima facie evidence that the desired results will be obtained."

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